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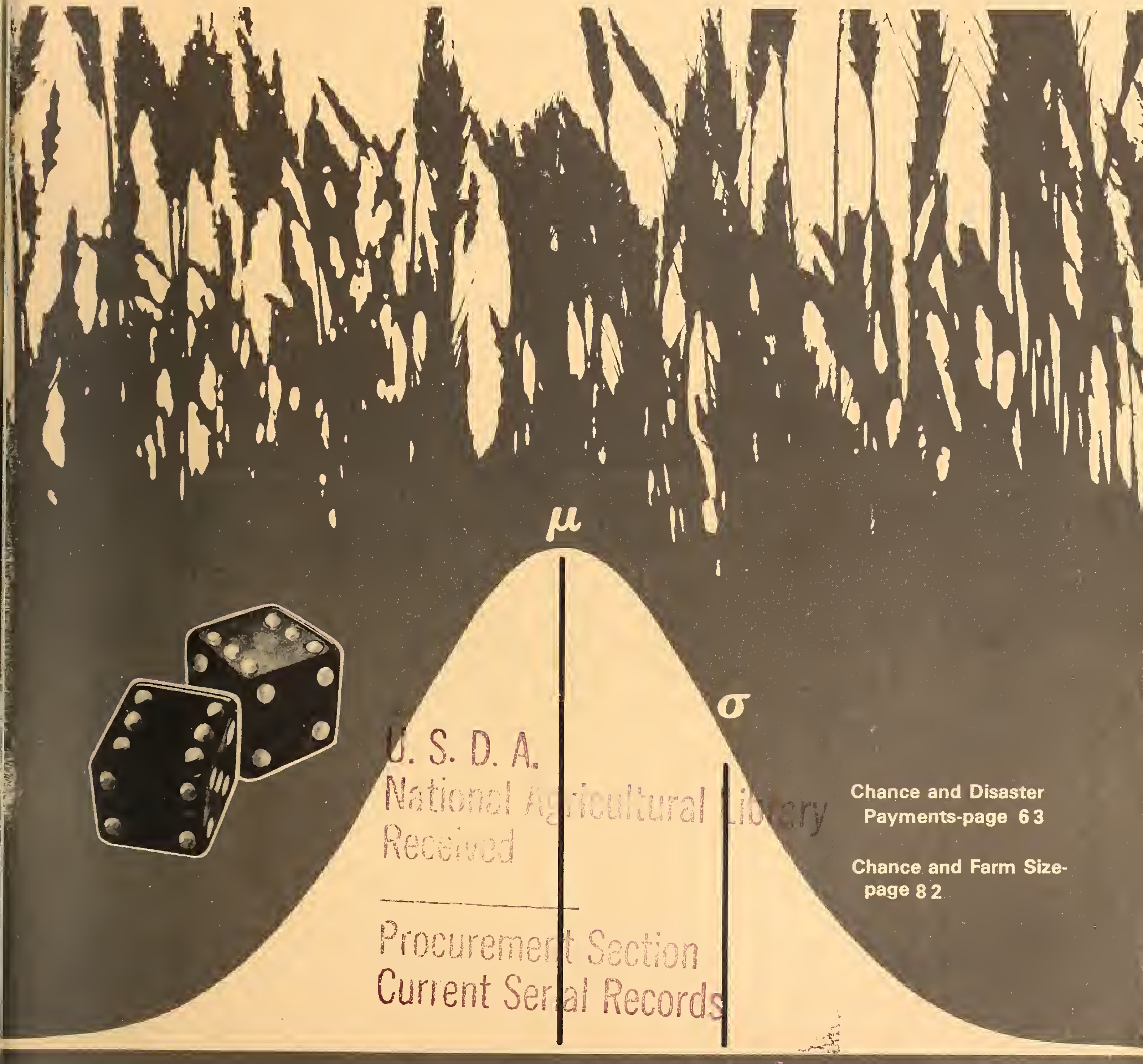




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# AGRICULTURAL ECONOMICS RESEARCH

## JULY 1977 VOL. 29 NO. 3

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# A STOCHASTIC MODEL OF DISASTER PAYMENTS UNDER THE 1973 FARM ACT

By Thomas A. Miller and Ronald H. Millar*

A stochastic computer simulation model is used to estimate disaster payments under the Agriculture and Consumer Protection Act of 1973. The model uses a random yield generator and actuarial techniques. Simulated payments under 1976 program parameters and stochastic yields are estimated at $300 million, compared with actual payments of $522 million in 1974 and $262 million in 1975. A payment greater than $522 million will probably not occur again under current conditions. The $262 million level is closer to normal expectations. The model also evaluates the impact of revisions in the payment program, as well as the effect of uncertain crop yields.
Keywords: Disaster Payment Program, disaster payments, crop insurance, risk, agricultural and food policy.

A stochastic simulation model was developed to aid research on Government protection of producers from income losses when crops are damaged by natural disasters (*5, 6, 7*).[1] Estimates of future Government costs of the various disaster program options are important for program development and administration. In this article, we review the Disaster Payment Program (DPP) of the Agriculture and Consumer Protection Act of 1973, describe the structure and application of the simulation model, and provide estimates of expected costs of the current DPP under possible conditions in 1976.

## THE DISASTER PAYMENT PROGRAM

Under the Disaster Payment Program, farmers can be reimbursed for some of the income lost because of crop failures. The program, administered by USDA's Agricultural Stabilization and Conservation Service (ASCS), covers corn, grain sorghum, barley, wheat, and upland cotton (*1, 2*).[2] The act of 1973 states:

> If the Secretary determines that, because of such a disaster or condition, the total quantity of wheat (or other nonconserving crop planted instead of wheat) which producers are able to harvest on any farm is less than 66-2/3 percent of the farm acreage allotment times the projected yield of wheat (or other nonconserving crop planted instead of wheat) for the farm, the rate of payment for the deficiency in production below 100 percent shall be . . . one-third of the established price.

Similar provisions exist for feed grains and cotton, and a payment is made if a producer is prevented from planting a program crop on his allotment acreage. However, we consider only the low yield portion of the DPP.

Under the DPP, producers who plant within their allotments are eligible for payment when their actual yield is less than their disaster yield (defined by ASCS as two-thirds of their historical yield). Producers who plant in excess of their allotment must have a substantially lower actual yield to be eligible, since production from total acreage is counted in determining eligibility for payment on the allotment acreage. A number of questions have been raised concerning how ASCS defines the disaster yield (*9*) and how basing the program on existing allotments reduces or denies coverage to producers who overplant (*5, 6, 9*). However, such questions are beyond the scope of this analysis, except in the sense that the simulation model provides the capability for evaluating modifications in the legislation.

Treasury costs under the DPP can vary greatly from year to year, depending primarily on crop yields. The model helps to ascertain whether payments, such as the $522 million in 1974 and $262 million in 1975, represent typical costs of the program, or whether they are extremes not likely to be repeated. Uncertainty concerning the expected costs of the DPP has led to difficulties in the budgeting process, as well as misgivings concerning the program's appropriateness as a vehicle to ameliorate farmers' uncertainty. Policymakers need estimates of future payments under the disaster provisions of the 1973 act to (a) improve the budgeting process, (b) evaluate the effectiveness of the current legislation, and (c) evaluate proposed modifications of the current legislation.

## MODEL STRUCTURE AND PROCEDURE

The stochastic computer simulation model generates a sample of expected crop yields, and computes payments for each of them using insurance actuarial methods and the parameters of the particular disaster payment program being evaluated. Lastly, the model accumulates results in the form of probability distributions of the expected payments.

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*Thomas A. Miller is an Agricultural Economist with the Commodity Economics Division, ERS, stationed at Colorado State University, and Ronald H. Millar is a Research Associate at Colorado State University.

[1] Italicized numbers in parentheses refer to items in References at the end of this article.

[2] The program was later extended to rice with passage of the Rice Production Act of 1975.

## The Required Parameters

The computer program uses two types of data—the specific parameters of the DPP provisions being analyzed and the parameters of the yield distributions. DPP parameters shown in table 1 include the disaster yield, the established yield (determined by ASCS), the payment rate, and the allotment or base acreage for each of the five program crops. Tables 2 and 3 show the crop yield parameters required by the model—the trend and expected value of future crop yields, the variance around this trend, the correlations between the yields of the different crops, and the standard deviations of all producer yields over space within the crop year being considered. The specific procedures used in estimating DPP costs and crop yield parameters will be described later after the general characteristics of the random yield generator, payment computation procedures, and model results are discussed.

Table 1.—Parameters for the 1976 Disaster Payment Program

| Crop | Disaster yield | Established yield | Payment rate | Allotment or base |
|---|---|---|---|---|
| | *Bushels* | | *Dollars* | *Million acres* |
| Corn | 53.565 | 89.0 | 0.520 | [1] 61.055 |
| Grain sorghum | 35.600 | 58.0 | .500 | [1] 16.137 |
| Barley | 28.057 | 44.4 | .430 | [1] 11.808 |
| Wheat | 19.897 | 32.6 | .760 | 61.600 |
| Cotton | [2] 310.800 | [2] 551.0 | .144 | 11.000 |

[1] See text for computation of feed grain base. [2] Cotton yield shown in pounds.

## The Random Yield Generator

A hypothetical sample of yields is drawn from the yield population by use of a random number generator. A multivariate normal distribution of yields is assumed for the five crops. The assumption that yields follow a multivariate normal distribution over time is not unrealistic for this purpose at the U.S. level, although for smaller geographic areas, the distribution sometimes becomes noticeably skewed. Yields in one year are assumed independent from yields in the previous year. While this assumption may not be realistic, it does not affect the average distribution of disaster payments.[3]

## Payment Computation Procedures

The disaster payment for each crop is computed as a function of the fixed DPP parameters and the randomly chosen U.S. average yield, considering each sampled observation as if it were a year. The conceptual linkage between national average yields and the amount of the disaster payment comes from crop insurance actuarial methods. The procedure resembles one used earlier by the Federal Crop Insurance Corporation in estimating annual loss-costs for setting all-risk crop insurance premiums (*8*, Ch. 18). For a given year and crop with an average U.S. yield, the actual yields of all producers are assumed normally distributed with a specific standard deviation. This standard deviation reflects the variation of yields with respect to space, not time. In figure 1, $Y_i$ represents the average U.S. yield for the crop. The

[3] Of course if there were correlation among years, the level of payments in one year would be affected, given the yields of the previous year. Both the independence and skewness properties of U.S. crop yields are evaluated by Luttrell and Gilbert (*4*). However, their conclusions do not apply directly to the yield distributions used in this article, since their analysis is based on yields per harvested acre while the disaster payment question involves yields per planted acre.

Table 2.—Estimated 1976 yield parameters for the simulation model

| Crop | Expected yield | Variance-covariance matrix: Corn | Grain sorghum | Barley | Wheat | Cotton |
|---|---|---|---|---|---|---|
| | *Bushels* | | | | | |
| Corn | 85.650 | 80.100 | 34.324<br>(.778) | 13.959<br>(.487) | 7.627<br>(.358) | 103.045<br>(.291) |
| Grain sorghum | 45.050 | | 24.300 | 4.578<br>(.290) | 1.936<br>(.165) | 32.376<br>(.166) |
| Barley | 42.660 | | | 10.257 | 2.912<br>(.382) | 0.000<br>(.000) |
| Wheat | 29.024 | | | | 5.666 | 32.398<br>(3.44) |
| | *Pounds* | | | | | |
| Cotton | 433.900 | | | | | 1,565.436 |

Table 3.—Estimated variation of producer yields over space within a crop year

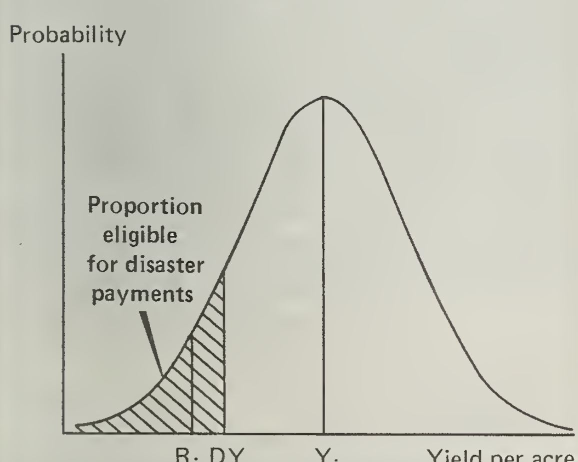
| Crop | Standard deviation | Coefficient of variation |
|---|---|---|
| | *Bushels* | |
| Corn | 17.609 | 20.2 |
| Grain sorghum | 5.709 | 11.5 |
| Barley | 5.914 | 13.9 |
| Wheat | 5.807 | 20.0 |
| | *Pounds* | |
| Cotton | 117.911 | 27.2 |

normal distribution serves as a proxy for the yields of all producers of that crop in that year.

Next we assume the DPP provides payments to all producers with yields lower than a specified, national average disaster yield (DY in figure 1). The proportion of producers that are eligible is represented by the hatched area to the left of DY. For all eligible producers, the average yield used in determining the total payment may be estimated as the average of all yields in the shaded portion, or $R_i$ in figure 1. Since the standard deviation of this distribution of yields is fixed for a given year and crop, knowing $Y_i$ enables computation of (a) the proportion of all producers that will be eligible for payment, and (b) the average yield of these producers.

Mathematically, the proportion of producers that are eligible is represented by the definite integral

FIGURE 1
**Assumed distribution of all U.S. producer yields in one crop year**




$$E_i = \int_0^{DY} f(x)dx \tag{1}$$

where

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-Y_i)^2/2\sigma^2} \tag{2}$$

with $\sigma$ representing the standard deviation of producer yields over space within a year. The average yield of these producers ($R_i$ in figure 1) is shown by

$$R_i = \frac{\int_0^{DY} xf(x)dx}{E_i} \tag{3}$$

which represents the weighted average of all eligible producer yields under the normal curve from zero to DY.

The payment is computed as the product of (1) the difference between the yield of the eligible producers and the national ASCS-established yield, (2) the percentage of all eligible producers, (3) the payment rate, and (4) the allotment for the crop in question, or

$$P_i = (EY - R_i) E_i rL \tag{4}$$

where

EY = the national average ASCS-established yield,
$r$ = the payment rate per unit of production, and
L = the total allotment or base acreage of the crop.[4]

## Tabulation of Results

The payment estimated for each crop in each sample observation is used to form the frequency distribution of payments over the entire sample. First, frequency distributions are tabulated for each crop, and the distribution of the total payment for all five crops is tabulated. Second after payments have been estimated for all sample observations, the program prints the mean values of the payments for each crop and for the total, and the frequency distributions for each crop and for the five-crop total. Also, the medians, quartiles, and percentile points can be determined from the frequency distributions as can the probability that payments will exceed a given level.

[4] This highly simplified procedure for estimating disaster payments contains numerous specification and aggregation errors. Implicitly it assumes that the average acreage of eligible producers equals the average acreage of all producers and that all producers plant within their allotment. However FCIC used a similar procedure with some success at the county level as mentioned earlier (*8*, Ch. 18). With the refinements discussed in a following section, the procedure was found to estimate aggregate disaster payments with reasonable accuracy.

## APPLICATION AND REFINEMENTS OF MODEL

### The Basic Data

Table 1 contains the estimated parameters for the 1976 DPP provisions. ASCS determines a disaster yield and an established yield for each county and farm participating in the program. (The established yield is sometimes called the projected yield, the program yield, or the farm payment yield.) The data in table 1 represent estimated 1976 national averages of the ASCS values. The disaster yields are estimated as two-thirds of the 10-year U.S. average yield per harvested acre for the respective crops. The established yields in table 1 are estimated on the basis of projecting the trend of historical established yields published by ASCS. The payment rates per unit of production and the national allotments or bases for the program crops for 1976 are also shown.

Since ASCS does not currently publish the base acreages for the individual feed grains, the total feed grain base for all crops has been allocated to corn, grain sorghum, and barley based on the proportions published by ASCS in 1973. All table 1 parameters were estimated before 1976 program statistics were available; thus, the data differ slightly from data later estimated by ASCS. However, the method used in computing the spatial standard deviations of table 3 provides a calibration procedure that corrects for these minor differences.

Table 2 presents crop yield parameters. While the DPP yield parameters are defined in terms of yields per harvested acre as required by the program, the parameters for the actual crop yields shown in table 2 are expressed in crop units per planted acre. These definitions correspond to the ASCS practice of determining DPP eligibility by comparing the actual production per planted acre (table 2) with the disaster yield (table 1). The expected values of yields are estimated using OLS regression and 1929-75 data. Linear time trends are segmented by dummy variables to reflect changes in the rate of increase. The wheat yield trend steepened in 1945, and that for barley in 1957, but cotton stabilized after 1963. The corn trend steepened sharply in 1956, and grain sorghum shifted upward in the same year; however both these crops lost most of the uptrend after 1970, along with a substantial increase in variance at that point, as recently discussed by Fox (*3*).[5]

The variance-covariance matrix is estimated from the residuals around the trend lines. The variance for wheat and barley remained constant over 1929-75; therefore, residuals for a 47-year period have been used to estimate variances. For cotton, the variance increased in the latter part of this yield history, and the 1957-75 residuals were used. For corn and grain sorghum, the higher 1970-75 variance is reflected in table 2. The values in parentheses below the covariances are the simple correlation coefficients represented by the respective covariances. It is important to include these relationships in the model since their existence makes a high payment for crop A likely in the same year that a high payment occurs for crop B, thus increasing the likelihood of a large total disaster payment.

The standard deviations of the distributions of individual producer yields over space denoted by $\sigma$ in equation (2) are determined last. The only readily available method for estimating the necessary standard deviations is to equate them to the levels implied by the actual ASCS payment history for each crop in 1974 and 1975 (*1*, *2*). Using 1974 and 1975 data, all of the variables and parameters of equations (1) through (4) can be known, except $\sigma$. The averages of the 1974 and 1975 standard deviations derived in this manner were used to estimate $\sigma$ in the 1976 simulations, and they appear in table 3.

Estimating the required spatial standard deviations so that the model duplicates historical data has a special advantage—it provides a calibration procedure for the model that corrects it for many of the specification and aggregation problems described earlier. Such a calibration also enables the model to duplicate how the DPP is actually administered by ASCS, as opposed to how it may appear to operate in the abstract.

### Model Refinements

The final simulation model was based on the concept of figure 1 with one additional refinement. The procedure described above was found to underestimate payments in situations where the disaster yield was less than 50 percent of the average yield. The combination of a very low disaster yield and a very high crop yield resulted in an eligibility estimate approaching zero for that year. However, experience of the crop insurance industry suggests that zero eligibility would not be expected under such conditions as some producers suffer losses even when overall yields are high. Therefore a minimum 2-percent eligibility level was used in all cases where the normal distribution showed an eligibility level lower than 2 percent.[6]

This minimum eligibility level necessitates revision of computation formulas. Equation (1) showing the proportion of producers eligible ($E_i$) now becomes

$$E_i = 0.02 + 0.96 \int_{A}^{DY} f(x)\,dx. \tag{5}$$

[5] In computing a farm's production for disaster payment purposes, ASCS values a ton of silage as equivalent to 5.5 bushels of grain. This factor was used for all historical data in estimating the yield parameters. However, even with this silage equivalent included in the expected yields of table 2, they remain much lower than the ASCS-established yields of table 1, especially for grain sorghum and cotton. This discrepancy reflects how the DPP is defined and administered and does not represent an error in the model (see *9*).

[6] In a similar manner, FCIC established a "minimum annual loss-cost" to use in years when the normal curve procedure showed an unrealistically low loss-cost (*8*, p. 251).

The integral is scaled down by a factor of 0.96 to compensate for the added area. For these computations, the lower limit of integration, A, has been set at $Y_i - 2.96\sigma$, a level that reduces the computer cost of evaluating the integral and provides a smooth transition zone as eligibility increases from 0.02.

The average yield of eligible producers from equation (3) now must be modified as shown by

$$R_i = \frac{(A/2.0)0.02 + 0.96 \int_A^{DY} xf(x)dx}{E_i} \quad (6)$$

which represents the weighted average of the yield for the minimum 2 percent eligible and the yield for the area under the normal curve from A to DY. When $A > DY$, $E_i = 0.02$ and $R_i = DY/2.0$, which represents the minimum payment level.

The payment computation procedure, refined to include the minimum 2-percent eligibility level, now uses equations (5), (6), and (4). Figure 2 depicts how the model computes a payment under low, medium, and high U.S. crop yields. The figure shows the disaster yield for the year in question, DY, and the established yield guaranteed to eligible farmers under the current disaster program, EY. For a year in which the yield is low ($Y_1$, Panel A), the hatched area represents eligibility $E_1$. The rectangular segment at the left of the frequency distribution represents the 0.02 minimum eligibility added to the normal curve. Medium and high yield situations appear in panels B and C, respectively (fig. 2). The total hatched area decreases as the U.S. yield increases—that is, the proportion of producers who qualify for disaster payments decreases as U.S. yields increase.

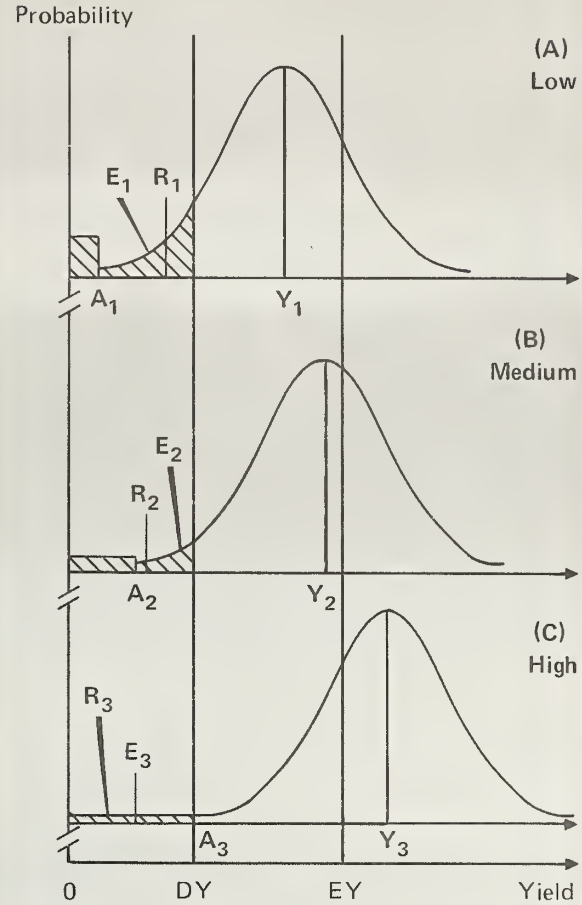
Note that the method shown in equation (6) to compute the average yield of eligible producers causes their yields ($R_i$) to decrease as average U.S. yields increase. This assumption is correct to the extent that two conditions exist. First, a relatively constant number of producers have a complete crop failure (zero yield) in each year. Second, decreases in U.S. average yields are related to an increase in the number of producers with yields close to the disaster yield level rather than an increase in the number of complete crop failures. This assumption represents the pessimistic view of the relationship between program eligibility, U.S. yields, and the yields of eligible producers. It is pessimistic in the sense that the estimated payment may be biased upward under the situation of a high U.S. yield and a low disaster yield. Therefore, computations using this model are less likely to underestimate total program costs.

## ESTIMATED COSTS OF THE 1976 DPP

Given the model structure and parameters, the simulation model computes and tabulates the payments that would result if all cultural practices (fertilizer, planting rates, technology, etc.) and DPP parameters are held constant at the 1976 level and all random factors (weather, crop disease, and other natural hazards) are allowed to repeat 1,000 times. Figure 3 shows the expected distribution of payments computed under these assumptions. The expected value or average payment for the 1976 program is $300 million and the median payment is $267 million. As a basis for comparison, payments under the low yield portion of the 1974 DPP were $522 million, payments under the 1975 DPP were $262 million, and preliminary estimates for the 1976 DPP are $452 million.[7] These are actual payments for single years, compared with the 1,000 observations of expected payments data represented in figure 3.

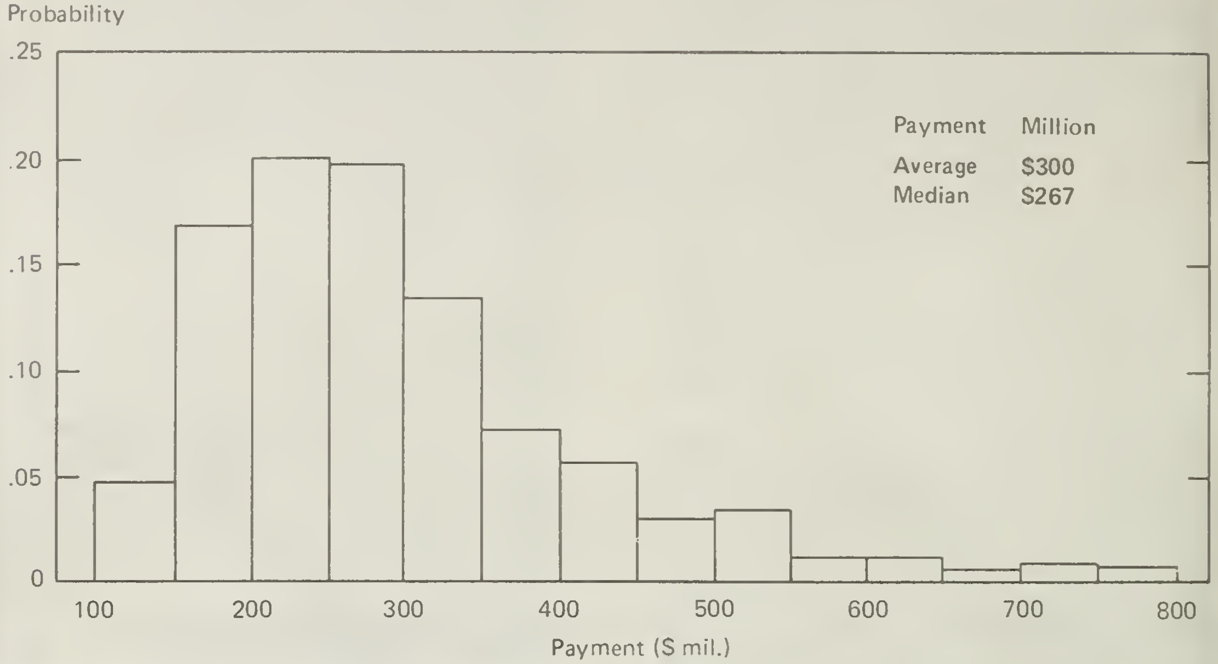
A payment of less than $150 million would occur 5

FIGURE 2
Disaster payment computation procedure under three yield levels for U.S. crops




[7] The $452 million is a preliminary estimate based on ASCS data as of April 21, 1977. Final, complete data for 1976 will not be available until fall 1977.

FIGURE 3
Expected low-yield payments under the current DPP, 1976




times in 100 and at the upper end, a payment of over $750 million would occur once in 100 (fig. 3). Thus the actual disaster payments in 1974 and 1976 were probably higher than what would be normally expected—the probability of a payment exceeding $522 million is only about 0.07 while the probability of exceeding $452 million is about 0.14. Because 1974 crop yields were much lower than expected, the likelihood of another disaster payment as large is small, given the same DPP parameters. Of the 3 years, the 1975 payment of $262 million is much more typical of the current DPP.

With a simulation model, the relative accuracy is usually determined through a validation procedure rather than statistically. In validation of the model used here, a large number of alternative assumptions and computational procedures were tested. The parameters fed into the current model provide estimates of 1974 and 1975 payments for all crops within 1 percent of the actual payments made by ASCS during these 2 years (*1*, *2*). In another validation exercise, the model was run several times to test the impact of errors in input parameters and of incorrect specifications in the mathematical relationships. The validation work suggests that the estimates of future payments and the type of information presented in figure 3 are likely to be within 10 percent of true real-world values.

Assumptions concerning crop yields underlie the model and its accuracy. These assumptions concern the trend and expected value of future crop yields, the variance around this trend, and the correlation between yields of different crops. If future average yields are lower than expected, or if the standard deviation around these trends is higher than expected, the costs of a DPP increase substantially.

## IMPLICATIONS

Since program and yield parameters are exogenous, the model provides the capability for analyzing the impact of alternative crop yields and modified DPP assumptions on program costs. For example the model can estimate the change in program costs that would result from changing disaster yields or the payment rate or from basing the payment on a yield that is less than the established yield. The model can also estimate the impact of changing allotments, as long as these are changed by the same proportion on all U.S. farms. However, the aggregate model cannot estimate the impact of changing the distribution of allotments among farms. Based on such capabilities, the model has been used to identify the impact of different yield assumptions and to estimate the impact of a number of modified disaster programs (*6*, *7*).

Such information can be useful in the 1977 congressional deliberations concerning disaster payment provisions in the next farm act. With appropriate modifications in the parameters of table 1 and estimates of $\sigma$, the model can estimate expected indemnity payments in new areas that may be covered by the Federal Crop

Insurance Corporation. Such indemnity estimates are critical in the process of setting crop insurance premium rates in new areas.

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### IN EARLIER ISSUES

The use of the term, government interference, as a synonym for government intervention has unfortunate connotations in the American vocabulary.

Kenneth L. Bachman
Volume I, Number 2, p. 67
April 1949

# ALTERNATIVE RETAIL BEEF-HANDLING SYSTEMS

By Lawrence A. Duewer and Terry L. Crawford*

Costs of seven methods of handling beef by retail firms are explored, considering number and size of stores per firm and distance from the packer. The least costly method is centralized cutting into retail cuts by retail firms. Larger store size reduced per unit costs significantly for all systems studied, while number of stores per firm affected costs only slightly.

Keywords: Beef fabrication, boxed beef, centralized beef cutting, retailer beef costs.

## INTRODUCTION

In the traditional beef handling system, the packer delivers carcass beef to the local retail store where it is cut into retail cuts. Some disadvantages exist, such as the need to transport excess fat and bone, the lack of economies of size in cutting operations, and the need to merchandise the whole carcass; hence, the search for other alternatives.

### The Search for New Systems

Several such systems have been proposed and tried by retailers to lower meat-handling costs. Here, we look at cost differences among seven systems for moving beef from packer to consumer. Our research demonstrates that "boxed beef" does not appear to provide the great savings frequently attributed to it. Boxed beef is so called because the packer breaks the carcass into smaller cuts, vacuum packs them, and ships them to the retailer in boxes.

Changes from the traditional system began 15 or more years ago and have been accelerating (*7*).[1] An estimated two-thirds of the beef entering supermarkets in 1974 was no longer arriving in carcass form (*1*). Some was being precut at the packing plant; the rest was cut in wholesale fabrication centers and retail chain warehouses. Boxed beef claims about one-fourth of the movement to retail stores, and perhaps a third of the beef is broken at retail warehouses. Only 2 to 4 percent of the beef now enters the retail store as fresh or frozen packaged retail cuts.

### Previous Studies

Analyses of alternative meat-handling systems began several years ago (*9*; *5*; *10*; *4*, pp. 35-46; *6*). All the authors suggest that cutting beef prior to receipt by the retail store has cost advantages, and some indicate that cutting and packaging to retail cuts at the retail warehouse is the least costly.

The Volz and Marsden report (*9*) has considerable detail on investment costs, as our study does, but the comparisons of cost per weekly dollar sales volume and per retail pound sold are difficult. Building shell cost of \$8 per square foot in the Volz and Marsden report, released in 1963, compares with \$25 to \$45 in this article, an increase due mostly to inflation. Wages per hour are two to three times higher in our study. In both studies, labor usage was reduced by about one-half when automatic wrapping machines rather than manual wrapping were compared.

The building shell cost in the Weatherly, Earle, and Brown study, released in 1967, was about \$12 per square foot (*10*). Labor was given in man-hours per year for different annual poundage volumes. Erickson and Lichty compared 11 alternative handling systems (*4*, pp. 35-46) while we examine 7. Results appear fairly consistent, although the total costs are less in their study. Inflation explains part of this difference. While Erickson and Lichty probably had to gather much of the detail needed, they do not include it, so we could not compare differences between their results and ours.

## METHODOLOGY

In this article, we use economic engineering and capital budgeting to evaluate the potential impact of various beef-handling systems on meat distribution costs. An example of an economic engineering technique used in our research is a time and motion study wherein data were obtained by a time-paced movie camera operating at two frames per second.

A systems analysis was undertaken at the beginning to identify those functions which would change as the alternative systems were adopted. Incremental factors of physical coefficients, variable costs, capital requirements, capital costs, and other costs were measured for each system. The information was cast in a traditional budgeting framework. We examined variations among alternative systems, and differences for chains with

*Agricultural Economists with the Commodity Economics Division and the National Economic Analysis Division, respectively, ERS.

Note: A Glossary appears at the end of this article.

[1] Italicized numbers in parentheses refer to items in References at the end of this article.

varying numbers and sizes of stores at varying distances from meat supply areas.

## THE SYSTEMS

Data for the study were collected and developed for ERS by Case and Company, a private management consulting firm. Seven systems were analyzed from the retailer's viewpoint:

- Carcasses from packer, usually moving as quarters, fabricated to primals at the retailer's central warehouse with retail cuts prepared at retail stores;
- Carcasses from packer fabricated to subprimals at the retailer's warehouse with retail cuts prepared at retail stores;
- Carcasses from packer fabricated to fresh retail cuts at the retailer's warehouse before distribution to the stores;
- Carcasses fabricated to frozen retail cuts at the retailer's warehouse before distribution to the stores;
- Packer-cut primals (boxed beef) distributed through a retailer's warehouse to retail stores;
- Carcasses from packer delivered direct to the store, without going to the retailer's warehouse;
- Packer-cut primals (boxed beef) delivered direct to the retail store, without going to the retailer's warehouse.

These seven do not include all possible systems, such as combinations, but they do represent the main ones.

Some of the distribution systems include the ability to adjust the proportions of the various beef cuts purchased to fit the demands of customers. However, the same mix of cuts is assumed for all systems. To facilitate cost comparisons among systems, the costs of inflexibility were included in the cost of merchandising slow-moving cuts (see Glossary). This results in higher costs to the systems that have less flexibility, ranging from 4.3 cents per retail pound for direct carcass delivery to store—system 6, to 0 cents for centralized cutting and packaging to frozen retail cuts—system 4. All systems involve conversion of shanks and plates and most of the flank to ground beef.

## DATA AND ASSUMPTIONS

The mix of cuts and the price data used were affected by the time when data were gathered, the summer and fall of 1975, which was not typical of the previous decade. The selloff period of the cattle cycle occurred in 1974-76, and relatively high grain prices reduced the number of cattle fed. A relatively large proportion of "nonfed" beef was marketed and a larger proportion of ground beef was sold. The peak in numbers in the cattle cycle was reached early in 1975. Increased slaughter of nonfed or shorter fed steers and heifers meant lower-than-Choice table beef was sold at lower retail prices, or was used to increase the supply of ground beef. The mix used, reflecting summer and fall 1975 data for several chains contacted, was 3 hind quarters for every 2 forequarters and 50 pounds of additional lean beef purchases (for ground beef production) per quarter purchased.

The volume of beef moved for various store classes is presented in table 1. The volume of beef moving through each retail outlet of a particular size is assumed the same, regardless of distribution system. Two store sizes are examined: the smaller stores move about 2,500 retail pounds of beef a week and the larger stores, about 10,000 pounds. Chain warehouse volumes vary from 25,000 pounds weekly to over 2 million pounds.

The fore-to-hind purchase ratio affects the costs of all systems fairly equally, and it has little effect on system rankings. In the "Results" section, we outline effects of a decrease in the percentage of ground beef sold.

Several factors for which it is difficult to determine costs were not included in the analysis. These include: flexibility in sales plans, differences in handling inventories, labor relations problems, and management convenience. While the cost of a given level of inventories could be determined, the sales lost due to insufficient inventory could not be determined. An important assumption, especially for the frozen system, is that consumers were indifferent to the various systems. Existing labor agreements which may favor or require one alternative over another are also not considered.

## COSTS CONSIDERED

Relevant costs in evaluating the best meat-handling system are those that would vary depending on the system used.

### Cost Concepts

Some costs, such as checkout labor, trays and film, display cabinets, and various overhead costs, which are not affected by the choice of the system, were not studied. Estimates of these costs are introduced later. Only the portions of the meat-handling systems that involve the retailer are included. Internal costs of packers are not included.

About half to two-thirds of the total costs in the carcass to retail price spread for beef, which amounted to 41 cents per retail pound in 1975, are explicitly considered in the analysis. Cost components were examined and computed in considerable detail, but only the more relevant items will be discussed.

We considered three cost categories:

1) Investments, both for the central retail warehouse and the store,

2) Operations: labor at retailer's warehouse and at store, warehouse and store support, transportation from warehouse to store, price difference between buying



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Table 1.—Situations analyzed by selected store size and number of stores per chain[1]

| Fresh beef movement per week | Small stores (Beef volume-2,505 lbs per week) | | | Large stores (Beef volume-10,020 lbs per week) | | |
|---|---|---|---|---|---|---|
| | 10 | 50 | 200 | 10 | 50 | 200 |
| | | | *Number* | | | |
| Front quarters purchased | 60 | 300 | 1,200 | 240 | 1,200 | 4,800 |
| Rear quarters purchased | 90 | 450 | 1,800 | 360 | 1,800 | 7,200 |
| Retail packages excluding ground beef[2] | 6,000 | 30,000 | 120,000 | 24,000 | 120,000 | 480,000 |
| Retail packages of ground beef[3] | 5,892 | 29,460 | 117,840 | 23,568 | 117,840 | 471,360 |
| | | | *Pounds* | | | |
| Pounds of lean purchased[4] | 7,500 | 37,500 | 150,000 | 30,000 | 150,000 | 600,000 |
| Pounds of ground[5] | 14,730 | 73,650 | 294,600 | 58,920 | 294,600 | 1,178,400 |
| Total retail pounds[6] | 25,050 | 125,250 | 501,000 | 100,200 | 501,000 | 2,004,000 |
| | | | *Dollars* | | | |
| Dollar volume at $1.50 per retail pound: | | | | | | |
| Per store | 3,758 | 3,758 | 3,758 | 15,030 | 15,030 | 15,030 |
| All stores | 37,580 | 187,875 | 751,500 | 150,300 | 751,500 | 3,006,000 |
| | | | *Miles* | | | |
| Average miles from retail warehouse to store | 20 | 30 | 40 | 20 | 30 | 40 |

[1] All situations for both small and large store chains assume retail warehouse locations both 125 miles and 1,000 miles from packer. [2] 31 packages from each front quarter plus 46 packages from each rear quarter. [3] Average 2.5 pounds per package. [4] 50 pounds for each quarter (from a sample of chains). [5] 65 pounds from each front quarter plus 37 pounds from each rear quarter plus 50 pounds of lean for each quarter. All usable trim converted to ground. [6] 129 pounds from each front quarter plus 109 pounds from each rear quarter plus pounds of lean beef purchased.

carcasses and boxed beef, shrinkage loss, and bone and fat salvage values,

3) Other factors: merchandising slow-moving cuts, labor coverage at stores (see Glossary); control of product, and control of accounting.

## Investment Costs

Investment costs are for building and equipment of the retailer's central warehouse (where applicable) and of the stores. Retail warehouse investment comprises five cost categories: receiving and shipping dock; carcass holding cooler; processing area; selection area; and administrative and general items. Both warehouse and store investment costs were divided into a number of subcategories.[2]

The investment in each piece of equipment or in floor space was spread over the expected life and discounted at 10 percent per year. Costs are based on new stores and equipment. Annual costs were divided by pounds sold per year to estimate cost per pound. Investment items comprised about 15 to 20 percent of all costs considered. Note that our costs may not immediately apply if switching from one system to another occurs because some space and equipment can be converted when existing stores are being converted.

## Operational Cost

Labor requirements for the retail store were determined from standards for each of several direct-labor categories, and for maintenance and sanitation (table 2). Estimates are based on typical hourly costs in 1975. Similar standards were established for central retail warehouses. Direct-labor costs were estimated from

[2] For example, under "selection area" in warehouse costs, the following were considered: share of building shell; rack slots; carts for tote boxes; tote boxes; forklifts; forklift batteries and chargers; and pallets.

Store investment cost components studied include: receiving scales, rails, and pallet jacks; cooler building shell and rails; cutting room building shell; slicers; tenderizers; saws; grinders; tables; platters; platter carts; knives; wrapping area building shell and equipment; pricing equipment; display area building shell; and display cabinet.

Table 2.—Store labor standards in man-hours per unit and formulas used

<table>
<tr><th rowspan="4">Item[1]</th><th colspan="7">Leaves packer as—</th></tr>
<tr><th>Carcass</th><th>Carcass</th><th colspan="2">Primals</th><th>Carcass</th><th>Carcass</th><th>Carcass</th></tr>
<tr><th colspan="7">Leaves retail warehouse as—</th></tr>
<tr><th>(6)[2]</th><th>Primals<br>(1)</th><th>Primals<br>(5)</th><th>(7)[2]</th><th>Sub-primals<br>(2)</th><th>Fresh retail cuts<br>(3)</th><th>Frozen retail cuts<br>(4)</th></tr>
<tr><td></td><td colspan="7">Hours per unit</td></tr>
<tr><td>Receiving:<br>Per quarter<br>Per retail lb<br>Per lb lean beef</td><td><br>0.014<br>NA<br>0.000021</td><td colspan="4"><br>NA<br>0.000024<br>NA</td><td colspan="2"><br>NA<br>0.000031<br>NA</td></tr>
<tr><td>Cutting:<br>Per front quarter<br>Per rear quarter</td><td><br>1.16<br>1.15</td><td colspan="3"><br>1.01<br>0.99</td><td><br>0.82<br>0.75</td><td colspan="2">NA</td></tr>
<tr><td>Steak tenderizing:<br>Per front quarter<br>Per rear quarter</td><td colspan="5"><br>0.02<br>0.15</td><td colspan="2">NA</td></tr>
<tr><td>Grinding:<br>Per lb</td><td colspan="5">0.0023</td><td colspan="2">NA</td></tr>
<tr><td>Wrapping:[3]<br>Per package[4]<br>Fully automatic<br>Manual</td><td colspan="5"><br><br>0.0015<br>0.0032</td><td colspan="2">NA</td></tr>
<tr><td>Pricing:<br>Per package[4]<br>Fully automatic<br>Semi-automatic</td><td colspan="5"><br><br>0<br>0.0015</td><td colspan="2">NA</td></tr>
<tr><td>Display:<br>Per package</td><td colspan="7">0.0015</td></tr>
<tr><td>Maintenance labor:<br>Hours per week</td><td colspan="7">0.042 x beef cutting, grinding, tenderizing, wrapping, and pricing labor hours per week</td></tr>
<tr><td>Sanitation labor:<br>Hours per week</td><td colspan="7">0.17 x beef cutting, grinding, tenderizing, wrapping, and pricing labor hours per week</td></tr>
</table>

Note: Numbers in parentheses refer to systems. NA means not applicable.

[1] Wages per hour used were $9 per hour for receiving, cutting, steak tenderizing, and grinding; $8 per hour for maintenance; and $7 per hour for wrapping, pricing, display, and sanitation. [2] Delivered direct to store; does not go through warehouse. [3] Case and Company calculates that the fully automatic wrapper is the least expensive to own and operate at greater than 5,100 packages per week. Below 5,100, the manual is the least expensive. (This assumes that for each beef package there is one nonbeef package wrapped.) [4] The fully automatic is used with the fully automatic wrapper, and the semi-automatic, with the manual wrapper.

recent time and motion studies conducted for ERS by Case and Company. Cooperating packers and retailers either supplied data or allowed Case and Company staff to perform economic engineering studies of operation. These standards allow for short rest breaks and delays: fatigue and delay of 20 percent at the central plant and 30 percent at the store. The greater amount of downtime away from meat cutting at the stores is partly due to the need to respond directly to consumers and to fill the display case.

The data and methodology used for estimating product shrink are shown in table 3. A purchase shrink of 0.5 percent of the purchase weight is added when buying carcasses because it is common practice for the retailer

Table 3.—Product shrink cost at alternative purchase costs and retail sale prices[1]

| Cost per retail pound | Carcass | Carcass | Carcass | Carcass | Primals | Carcass | Primals |
|---|---|---|---|---|---|---|---|
| | Leaves packer as— | | | | | | |
| | Leaves retail warehouse as— | | | | | | |
| | Primals (1) | Sub-primals (2) | Fresh cuts (3) | Frozen cuts (4) | Primals (5) | ([6]) (6) | ([6]) (7) |
| | Cents | | | | | | |
| $1.10 purchase, $1.50 retail price | [2]3.10 | [2]3.10 | [3]2.05 | [3]2.05 | [4]0.60 | [5]2.05 | [4]0.60 |
| $0.95 purchase, $1.30 retail price | 2.68 | 2.68 | 1.78 | 1.78 | 0.52 | 1.78 | 0.52 |
| $1.25 purchase, $1.70 retail price | 3.52 | 3.52 | 2.32 | 2.32 | 0.68 | 2.32 | 0.68 |

[1] Lean beef used in each system is assigned the same amount of shrink. A purchase price of $1.10 and a retail price of $1.50 are the base prices used throughout the study. [2] (0.5 percent purchase shrink times $1.10 purchase price per retail pound) plus (0.5 percent shrink per day nonvacuum wrapped in warehouse times 2 days) plus (0.35 percent shrink per day partially vacuum wrapped in warehouse and store times 2 days) times $1.50 per pound at retail equals 3.10 cents per pound. [3] (0.5 percent purchase shrink times $1.10 purchase price per retail pound) plus (0.5 percent shrink per day nonvacuum wrapped in warehouse times 2 days) times $1.50 per pound at retail equals 2.05 cents per pound. [4] 0.4 percent total shrink times $1.50 per retail pound equals 0.60 cents per pound. [5] (0.5 percent purchase shrink times $1.10 purchase price per retail pound) plus (0.5 percent shrink per day nonvacuum wrapped in store times 2 days) times $1.50 per pound at retail) equals 2.05 cents per pound. [6] Direct delivered to the store, does not go through warehouse.

to pay for 100.5 percent of the weight received.

The rates of shrink by retail product weight sold are 0.5 percent per day for fresh nonvacuum wrapped meat; 0.4 percent for primals the packer vacuum wraps, until the package is opened; 0.35 percent per day for primals and subprimals the retailer centrally fabricates and partially vacuum wraps; and none for frozen meat. These rates are typical of rates in the meat industry (*10*). Average purchase cost of beef at the packer in carcass from during the study period was $1.10 per retail pound.

The periods for which the meat is held at the retail central warehouse were standardized at 3 days for each of the distribution systems. When the meat is fabricated, it is held for 2 days before fabrication and 1 day after. The average holding time in the stores is standardized at 2 days when meat is cut at the stores, 1 day before cutting and 1 day after; and at 1 day when the stores receive retail cuts. For direct delivery of carcasses to the stores, holding time in the store is 3 days; 2 days before cutting and 1 day after. No shrinkage is applied after the cuts are retail packaged.

Two distances between the packer and retail chain warehouse were considered: 125 miles and 1,000 miles. A transportation cost differential of 5.04 cents per retail pound was used to adjust to the additional cost of the longer distance.

Transportation from warehouse to local store is a factor for five systems. As the number of stores per chain division increases, the average distances increase (see table 1) and costs increase slightly. Firms with larger stores have about one-half cent lower costs than those with smaller stores, because each delivery is larger.

## Other Costs

The higher price paid for primals than for carcasses per retail pound appears as a cost to the retailer. The transportation savings reduce costs; fewer pounds are shipped when beef is cut to primals at the packing plant. During 1975, the retailer apparently paid an average of about 5.77 cents more per retail pound for boxed beef. This difference would be the return to the packer for fabrication, vacuum packaging, and putting the primals in cartons. It is difficult and somewhat subjective to match equivalent products to accurately estimate the price difference between purchasing a carcass and buying the same quantity cut into primals and other cuts. Thus, instead of only using the 1975 estimate, we present a range of values in table 4 so that someone using the data can apply a schedule of price differences from 3 cents to 7 cents per pound.

Retailers usually buy beef per pound, and they tend to maintain their accounting records by purchase weight. However, to compare different systems, we converted all costs to the basis of a retail pound sold.

An estimate of the retail price is combined with the physical coefficients to estimate the cost due to product shrink and the cost of merchandising slow-moving cuts. Computations and results are based on a $1.50 composite

Table 4.—Comparison of beef-handling systems for supermarkets for all costs considered with the purchase price difference between carcass and packer primals at various levels in cents per retail pound[1]

| Number and size of stores per firm[4] | 125 miles from packer to supermarket | | | | | | | 1,000 miles from packer to supermarket[2] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaves packer as— | | | | | | | | | | | | | |
| | Carcass | Carcass | Carcass | Carcass | Primals | Carcass | Primals | Carcass | Carcass | Carcass | Carcass | Primals | Carcass | Primals |
| | Leaves retail warehouse as— | | | | | | | | | | | | | |
| | Primals (1) | Sub-primals (2) | Fresh cuts (3) | Frozen cuts (4) | Primals (5) | (6)[3] | (7)[3] | Primals (1) | Sub-primals (2) | Fresh cuts (3) | Frozen cuts (4) | Primals (5) | (6)[3] | (7)[3] |
| 10 Small | | | | | | | | | | | | | | |
| 3 cents price difference . . . | | | | | 22.26 | | 20.94 | | | | | 25.73 | | 24.41 |
| 4 cents price difference . . . | | | | | 23.36 | | 21.94 | | | | | 26.73 | | 25.41 |
| 5 cents price difference . . . | 23.37 | 22.96 | 17.82 | 20.60 | 24.26 | 22.85 | 22.94 | 28.41 | 28.00 | 22.86 | 25.64 | 27.73 | 27.89 | 26.41 |
| 6 cents price difference . . . | | | | | 25.26 | | 23.94 | | | | | 28.73 | | 27.41 |
| 7 cents price difference . . . | | | | | 26.26 | | 24.94 | | | | | 29.73 | | 28.41 |
| 50 Small | | | | | | | | | | | | | | |
| 3 cents price difference . . . | | | | | 21.85 | | 20.94 | | | | | 25.32 | | 24.41 |
| 4 cents price difference . . . | | | | | 22.85 | | 20.94 | | | | | 26.32 | | 25.41 |
| 5 cents price difference . . . | 22.83 | 22.40 | 17.03 | 19.20 | 23.85 | 22.85 | 22.94 | 27.87 | 27.44 | 22.07 | 24.24 | 27.32 | 27.89 | 26.41 |
| 6 cents price difference . . . | | | | | 24.85 | | 23.94 | | | | | 28.32 | | 27.41 |
| 7 cents price difference . . . | | | | | 25.85 | | 24.94 | | | | | 29.32 | | 28.41 |
| 200 Small | | | | | | | | | | | | | | |
| 3 cents price difference . . . | | | | | 21.87 | | 20.94 | | | | | 25.34 | | 24.41 |
| 4 cents price difference . . . | | | | | 22.87 | | 21.94 | | | | | 26.34 | | 25.41 |
| 5 cents price difference . . . | 22.84 | 22.44 | 16.86 | 18.94 | 23.87 | 22.85 | 22.94 | 27.88 | 27.48 | 21.90 | 23.98 | 27.34 | 27.89 | 26.41 |
| 6 cents price difference . . . | | | | | 24.87 | | 23.94 | | | | | 28.34 | | 27.41 |
| 7 cents price difference . . . | | | | | 25.87 | | 24.94 | | | | | 29.34 | | 28.41 |
| 10 Large | | | | | | | | | | | | | | |
| 3 cents price difference . . . | | | | | 18.59 | | 17.86 | | | | | 22.06 | | 21.33 |
| 4 cents price difference . . . | | | | | 19.59 | | 18.86 | | | | | 23.06 | | 22.33 |
| 5 cents price difference . . . | 19.58 | 19.09 | 15.30 | 17.45 | 20.59 | 19.77 | 19.86 | 24.62 | 24.13 | 20.34 | 22.49 | 24.06 | 24.81 | 23.33 |
| 6 cents price difference . . . | | | | | 21.59 | | 20.86 | | | | | 25.06 | | 24.33 |
| 7 cents price difference . . . | | | | | 22.59 | | 21.86 | | | | | 26.06 | | 25.33 |
| 50 Large | | | | | | | | | | | | | | |
| 3 cents price difference . . . | | | | | 18.58 | | 17.86 | | | | | 22.05 | | 21.33 |
| 4 cents price difference . . . | | | | | 19.58 | | 18.86 | | | | | 23.05 | | 22.33 |
| 5 cents price difference . . . | 19.55 | 19.09 | 15.03 | 17.05 | 20.58 | 19.77 | 19.86 | 24.59 | 24.13 | 20.07 | 22.09 | 24.05 | 24.81 | 23.33 |
| 6 cents price difference . . . | | | | | 21.58 | | 20.86 | | | | | 25.05 | | 24.33 |
| 7 cents price difference . . . | | | | | 22.58 | | 21.86 | | | | | 26.05 | | 25.33 |
| 200 Large | | | | | | | | | | | | | | |
| 3 cents price difference . . . | | | | | 18.64 | | 17.86 | | | | | 22.11 | | 21.33 |
| 4 cents price difference . . . | | | | | 19.64 | | 18.66 | | | | | 23.11 | | 22.33 |
| 5 cents price difference . . . | 19.59 | 19.14 | 14.98 | 16.97 | 20.64 | 19.77 | 19.86 | 24.63 | 24.18 | 20.02 | 22.01 | 24.11 | 24.83 | 23.33 |
| 6 cents price difference . . . | | | | | 21.64 | | 20.86 | | | | | 25.11 | | 24.33 |
| 7 cents price difference . . . | | | | | 22.64 | | 21.86 | | | | | 26.11 | | 25.33 |

Note: Numbers in parentheses refer to systems.

[1] Costs that do not vary because of type of handling system are not included in most cases; see text for details. [2] Firms 1,000 miles from the packer have an additional 5.04 cents per retail pound cost over those 125 miles from the packer to reflect the transportation differences for all systems except 5 and 7. Since fewer pounds of primals are transported, the cost per retail pound sold is lower ($3.47) for the 5 and 7 systems. [3] Delivered direct to store, does not go through warehouse. [4] Each number and size of stores per firm category is computed at five different price levels for packer carcass price versus primal price (range used is 3 - 7 cents per retail pound).

retail price. The effect of higher and lower retail price assumptions on shrink estimates is shown in table 3. Retail prices significantly affect costs. The systems wherein the retailers buy carcasses involve more shrinkage loss than the systems wherein they buy vacuum-packaged primals. Thus, shrinkage costs of the boxed beef system are relatively lower at more distant points from the packer than those of the other systems.

Costs for the various systems are presented in table 4 and the figure. Costs for boxed beef in table 4 were computed using price differences varying from 3 to 7 cents per retail pound between boxed beef and carcass quarters. The figure is based on a price difference of 5 cents. Most of the discussion of results will be based on the 5-cent difference, apparently the current average for the industry.

## RESULTS

Centralized cutting to fresh retail cuts (system 3) is by far the cheapest system, whether a firm has few or many stores or these are small or large. Distance from the packer does not affect this ranking. Lower costs come mainly from labor savings, lower store support costs, and a smaller cost of merchandising slow-moving cuts.

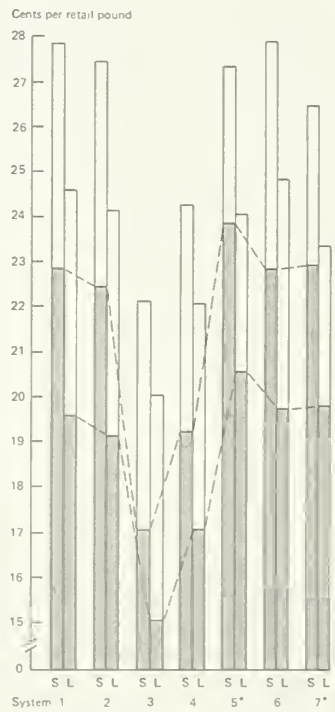
Central cutting to frozen cuts (system 4), however, has only slightly higher costs (about 2 cents per retail pound) than fresh cuts, and the products have a much longer shelf life. If consumers accept a switch to all frozen cuts, there could well be flexibility possible for management, not considered in this study, which would make the frozen system preferable over the fresh system. However, the 10-store small chain has significantly higher costs for the frozen cuts (system 4) because store volume is not large enough to make efficient use of the freezing equipment.

Number of stores per firm does not significantly affect the cost (except for the very smallest firms) of the systems studied, but the size does. Large stores (beef sales of about $15,000 per week) enjoy a 2-4-cent advantage over small stores (beef sales of about $3,760 per week), depending on the system. Small stores use equipment or building space less effectively. Large stores have about one-half cent less cost for plant to store transportation, as each delivery is larger. The figure indicates the difference in costs by store size and system, as well as the transportation cost differential (5.04 cents per retail pound for carcass).

### Ranking the Systems

Depending on the price difference used for boxed beef over carcasses, boxed beef can rank either as the

FIGURE 1
Costs for selected meat-handling systems, retailers with 50 stores per firm division, $1.50 per retail pound




*Assumes a price difference of 5 cents between boxed beef and carcasses.
Note Shaded portion of bar is cost when retail warehouse is 125 miles from packer, entire bar indicates costs at 1,000 miles.
S = small supermarkets. L = large supermarkets.

next lowest in cost (system 7) after the retail warehouse cutting to retail cuts (systems 3 and 4), or as the highest in cost (system 5). Assuming the 5-cent difference to buy primals, the third lowest cost system at 125 miles is the retail warehouse cutting to subprimals (system 2), while boxed beef delivered direct to the store (system 7) ranked third for firms 1,000 miles from the packer. The chart indicates all systems except the central cutting to retail cuts (systems 3 and 4), are very similar in costs. As the distance from the packer increases, the packer cut primal systems (5 and 7) become more attractive; transportation costs are lower because fewer pounds are moved.

Note that the boxed beef systems have the processing cost and profit included in the primal cost difference, whereas the retail warehouse breaking or cutting systems include processing costs but not profits.

For all store number and size classifications, it appears slightly more economical for retail warehouses to break carcasses to subprimals (system 2) rather than stopping at primals (system 1). The traditional carcass system (6) usually costs slightly more than if the retailer breaks to primals or subprimals (systems 1 or 2) at a warehouse. However, there does not appear to be a clear advantage; the traditional carcass system does not seem as inefficient as many persons have implied.

Chain warehouse receipt of vacuum-laminated, wrapped boxed beef delivered to the stores by the retailer (system 5) is more expensive than direct delivery to the stores by the packer of the same boxed beef (system 7). The first system requires extra handling in unloading and loading at the warehouse, and it ranks last in least cost for stores 125 miles from the packer. Its disadvantage is reduced relative to other systems with an increase in distance, ranking fourth at 1,000 miles from the packer.

## Specific Cost Example

To provide a more complete breakdown of costs, we show a specific situation in table 5. Detailed cost budgets appear for each meat-handling system for a 50-store chain. Stores average $3,760 in beef sales per week, and are about 1,000 miles from the packer. A 5-cent per pound packer primal price difference is used.

The base or zero value used in our study is carcass beef delivered to a retail warehouse 125 miles from the packer. Costs included are only those considered relative or additional to this base cost of the product. Table 4 uses this base. The additional transportation charge for delivery 1,000 miles from the packer to the retail chain warehouse is included in table 5. However, it is not the total transportation cost.

Table 5 provides subtotals for warehouse, store, and other costs. The data given for this specific example were completed for all situations examined and are available from the authors. Warehouse costs are the same regardless of distance, when the system, store size, and number of stores are compared. Store costs for a meat-handling system differ based on store size, but not on number of stores per chain. Alternatively, warehouse cost variations occur both as a result of the number and size of stores.

Total costs included in table 4 vary from about 15 to 25 cents per retail pound, not including transportation to the chain warehouses for supermarkets 125 miles from the packer. A similar range exists, but with about 5 cents added for transportation, for firms 1,000 miles from the packer.

Costs Excluded. Costs we included are mostly those that vary only by type of handling system. Other costs not considered that retailers incur include about 0.5 cent per retail pound for checkout labor, 2 cents for trays and film, 1.5 cents for advertising, 0.5 cent for interest, and 0.13 cent for display equipment. In addition, there are division headquarters expenses for management, accounting, ordering, and so on. A portion of the store management, the parking lot, and various other overhead expenses have not been included. A final cost would be profits. USDA price spreads for carcass beef indicate an average spread of about 41 cents during 1975 for total costs after the beef arrives in the city where it is consumed. Only a small portion of this spread is profits.

Ground Beef Percentage. The results presented are based on an abnormally high proportion of ground beef in the mix of products sold (59 percent of the total retail weight). This unusual share was a result of the market situation existing in 1975. When results were evaluated at a more normal hamburger percentage (29 percent), the ranking of the seven systems was found relatively insensitive to a change in mix of this magnitude (see table 6). Cost of all systems increases absolutely with a lower ground beef sales mix, and boxed beef cost (systems 5 and 7) rises at a slightly greater rate than in the other systems. Major changes occurred in the product purchase and labor cost areas.

## IMPLICATIONS

Based on results of our study, boxed beef is not necessarily as great a cost saver as many persons have assumed. The breaking to primals or subprimals at the packing plant has extra costs which counter the savings in labor and transportation. These include the cost of the vacuum bag and box. If the carcass is broken to retail cuts and packaged for the consumer, the meat need not be packaged twice. However, going to retail cuts right away means that fresh beef has only a few days shelf life; thus breaking would probably need to be done at a retail warehouse rather than at the packer. If the meat is frozen, it could be broken down either by the packer or the retail warehouse. A big question is whether the consumer can be convinced to buy mostly meat that is frozen. Central cutting by packers to retail

Table 5.—Detailed cost breakdown for chain of 50 small stores 1,000 miles from packer using $1.50 retail price per pound and packer primal price 5 cents more than carcass price[1]

| Costs considered | Leaves packer as— | | | | | | |
|---|---|---|---|---|---|---|---|
| | Carcass | Carcass | Carcass | Carcass | Primals | Carcass | Primals |
| | Leaves retail warehouse as— | | | | | | |
| | Primals (1) | Sub-primals (2) | Fresh cuts (3) | Frozen cuts (4) | Primals (5) | ([2]) (6) | ([2]) (7) |
| | *Cents per retail pound* | | | | | | |
| Warehouse: | | | | | | | |
| Investment | 0.72 | 0.79 | 1.39 | 1.76 | 0.32 | 0.00 | 0.00 |
| Labor | 1.34 | 2.65 | 7.14 | 7.14 | 0.15 | 0.00 | 0.00 |
| Support[3] | 0.47 | 0.70 | 0.81 | 3.15 | 0.10 | 0.00 | 0.00 |
| Total, warehouse | 2.53 | 4.14 | 9.34 | 12.05 | 0.57 | 0.00 | 0.00 |
| Store: | | | | | | | |
| Investment | 3.35 | 3.32 | 1.91 | 1.91 | 3.35 | 3.44 | 3.35 |
| Labor | 9.67 | 8.56 | 1.08 | 1.08 | 9.67 | 10.61 | 9.67 |
| Support[3] | 1.92 | 1.68 | 0.20 | 0.26 | 1.92 | 2.10 | 1.92 |
| Labor coverage[4] | 0.23 | 0.52 | 2.13 | 2.13 | 0.23 | 0.00 | 0.23 |
| Total, store | 15.17 | 14.08 | 5.32 | 5.38 | 15.17 | 16.15 | 15.17 |
| Other: | | | | | | | |
| Purchase premium[5] | 0.00 | 0.00 | 0.00 | 0.00 | 3.20 | 0.49 | 3.73 |
| Shrinkage[6] | 3.10 | 3.10 | 2.05 | 2.05 | 0.60 | 2.05 | 0.60 |
| Salvage income[7] | (0.97) | (1.24) | (1.40) | (1.40) | (0.26) | (0.53) | (0.26) |
| Warehouse to store transportation | 0.94 | 0.94 | 1.07 | 1.12 | 0.94 | 0.00 | 0.00 |
| Merchandising slow-moving cuts[8] | 1.94 | 1.29 | 0.65 | 0.00 | 1.94 | 4.31 | 1.94 |
| Control of product[9] | 0.12 | 0.09 | 0.00 | 0.00 | 0.12 | 0.31 | 0.12 |
| Accounting control[10] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.07 |
| Total, other | 5.13 | 4.18 | 2.37 | 1.77 | 6.54 | 6.70 | 6.20 |
| Transportation increase to 1,000 miles[11] | 5.04 | 5.04 | 5.04 | 5.04 | 5.04 | 5.04 | 5.04 |
| Total, costs considered | 27.87 | 27.44 | 22.07 | 24.24 | 27.32 | 27.89 | 26.41 |

Note: Numbers in parentheses in boxheads refer to systems. In field they denote negative amounts.

[1] Costs that do not vary by type of handling system are not included in most cases; see text for details. [2] Delivered direct to store, does not go through warehouse. [3] Includes maintenance, sanitation, carbon dioxide, electricity and so on. [4] Minimum labor required at store by union and for customer service. [5] Primal over carcass price difference and transportation relative to a carcass delivered to the retail warehouse. [6] Shrinkage explained in table 3. [7] Gain in value from fat and bone trim. [8] Includes the need to modify cut prices to move cuts in proportion purchased and display case pullbacks because of cut deterioration. [9] Costs incurred when consistent product trim is not maintained. [10] The additional accounting costs with direct delivery to stores. [11] The additional transportation cost per retail pound incurred by retail firms with warehouses located 1,000 miles from the packer compared with retailers with warehouses located only 125 miles from the packer.

cuts might reduce retailer merchandising flexibility as the packer standardizes cuts.

Centralization of the retail cutting process by retailers appears to have considerable cost advantages. Larger stores have economies of scale in handling meat over small stores, regardless of system used. When there were a greater number of stores per chain, significant economies did not occur.

Transition to a central system will not occur smoothly unless management and labor satisfactorily work out procedures to handle the labor displaced and to retire the existing capital facilities. Traditional carcass delivery to the store will probably not disappear from the scene, given its moderate cost ranking, particularly in areas near packing plants. However, in more distant areas, it is probable that a variety of systems will compete with each other, as the third through seventh ranked systems are fairly close together in costs.

Although very small stores and independents served by voluntary or cooperative wholesalers were not specifically considered, these retailers would not have the volume needed to operate a centralized cutting facility. However, affiliation with a wholesaler might give these stores the same advantage as a chain if services are per-

Table 6.—Cost sensitivity of moving from 59 to 29 percent ground beef (retail pounds), chain of 50 small stores 1,000 miles from packer[1]

| Cost item | Leaves packer as— | | | | | | |
|---|---|---|---|---|---|---|---|
| | Carcass | Carcass | Carcass | Carcass | Primals | Carcass | Primals |
| | Leaves retail warehouse as— | | | | | | |
| | Primals (1) | Sub-primals (2) | Fresh cuts (3) | Frozen cuts (4) | Primals (5) | ([2]) (6) | ([2]) (7) |
| | *Change in costs, cents per retail pound* | | | | | | |
| Warehouse grinding equipment | ([3]) | ([3]) | ([3]) | ([3]) | ([2]) | ([2]) | ([2]) |
| Warehouse cutting equipment | ([3]) | ([3]) | ([3]) | ([3]) | ([2]) | ([2]) | ([2]) |
| Product purchase premium[4] | 0(base) | 0(base) | 0(base) | 0(base) | +2.3 | 0(base) | +2.3 |
| Product salvage | 0.4 | 0.5 | 0.6 | 0.6 | 0.1 | 0.2 | 0.1 |
| Warehouse labor | 0.4 | 0.8 | 2.0 | 2.0 | 0 | ([2]) | ([2]) |
| Store labor | 1.5 | 1.1 | 0 | 0 | 1.5 | 1.9 | 1.5 |
| Merchandising slow-moving cuts | 0 | 0 | 0 | 0 | 0 | 0.4 | 0 |
| Labor coverage | 0.1 | 0.2 | 0.5 | 0.5 | 0.1 | 0(base) | 0.1 |
| Control of product | 0.1 | ([3]) | 0 | 0 | 0.1 | 0.2 | 0.1 |
| Total change (increase in cost) | 2.5 | 2.6 | 3.1 | 3.1 | 4.1 | 2.7 | 4.1 |

[1] Only those costs affected are listed. [2] Delivered direct to store, or not applicable. [3] Less than 0.005. [4] Would vary relative to difference used between carcass price and primal price.

formed by the wholesaler for them. For larger firms a centralized cutting plant (systems 3 and 4) seems to be less expensive than buying boxed beef (systems 5 and 7).

We did not, as mentioned, examine packer costs, but rather used the price differential between carcasses and packer-cut primals. A range of costs for different price differentials was provided in table 4 to show the sensitivity of the packer systems to others as price differentials vary. Only a few firms currently cut a carcass into retail cuts (systems 3 and 4). A fairly large number break a carcass to primals and subprimals before distributing to their stores. One reason there are few such retail centralized cutting operations is the large investment required and the sunk cost of existing facilities.

While we did not specifically address labor implications, we do include the amount and location of labor needed for each system. Systems 1 through 4 shift varying amounts of labor from the local store to the retailers' warehouse. The need to stock shelves and to provide customer service means all stores require some meat department personnel, but job descriptions and wage levels might differ if less cutting is done at retail. Many of the meatcutters not needed in local stores could be shifted to the retailers' warehouse where additional labor would be required. Since the warehouse might be across town, getting to work could be considerably more difficult unless the employee moves. Warehouse wage rates would probably be similar to store rates.

Systems 5 and 7, using boxed beef, shift a portion of the labor from the store or warehouse to the packing plant. This would probably mean a shift to another geographic area for the employee. The cutting functions shifted from the retailer to the packer are done by another firm in the boxed beef systems, making transfer of meatcutters more difficult than it would be in the same firm. Packers are normally located in production areas and these areas commonly have lower wage rates. Individual meatcutters may be unwilling to move and seek the lower paying jobs.

Moving a portion of the meatcutting to central warehouses or to packing plants allows for the use of disassembly lines and specialization of tasks. This efficiency is partially lost because some people must remain at local stores to stock and serve customers when the store is open. Thus, the number of people employed, while dropping slightly, is not as serious a problem as the relocation aspects. Centralization of meat cutting requires better forecasting of individual stores' demand for meat cuts. Forecasting can also help schedule labor more efficiently and possibly reduce the amount required.

Ultimately, specific characteristics of the firm and its management's judgment regarding intangibles will determine to a large extent the beef-handling system adopted. A firm viewing its competitive situation as favorable, and its pool of managerial resources as limited, may well opt for a particular system even though it may be slightly more costly. As retailers continue to sell beef in cut proportions different than those found in the animal, boxed beef offers advantages over systems requiring sale of the total carcass. Given consumer pressures for lower beef



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prices and the existing alternatives for handling meat, we can expect retailers to continue experimentation to meet consumer preferences efficiently.

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# GLOSSARY

*Boxed beef*—Beef cut to primals, subprimals, or both, vacuum-wrapped, and placed in cartons by the packer.

*Capital budgeting*—Series of decisions by individuals and firms concerning how much and where resources will be obtained and expended, setting standards for project acceptability, evaluating individual projects, and determining the source of capital to be used.

*Carcass proportion*—Amounts of each cut found in a beef carcass. When looking at retail cuts to obtain an accurate composite price, the user must weight all cuts as they are found in the carcass.

*Central breaking*—Carcasses broken to primals, subprimals, or both at the retailer's central warehouse.

*Central cutting*—Meat cut completely to retail cuts and packaged before delivery to local stores. It could be done by packers, but it is usually done at retail chain warehouses.

*Chain warehouse*—Central plant used by the chain to assemble, store, and distribute the product to local stores. In several of the systems examined, this facility processes the beef.

*Composite price*—Price of each cut weighted by its respective weight in the carcass.

*Cost per retail pound*—Cost per pound of beef sold. The records of pounds entering the retail store differ by system. Putting them all on a retail pound basis facilitates comparisons among systems.

*Fabrication*—Breaking and cutting of beef from carcass to retail cuts, wherever done and whether done partly or entirely.

*Fed beef*—Beef from animals fed rations that were largely grain for a period before slaughter.

*Industrial engineering approach*—Application of engineering techniques for collecting data on the operation of a large plant.

*Labor coverage*—Minimum labor required at store for customer service, regardless of volume, and to meet union agreements for staffing.

*Merchandizing slow-moving cuts*—The modification of prices to move cuts in proportion to purchases and to loss from product deterioration.

*Nonfed beef*—Beef from animals mainly fed grass or roughage, with little or no grain.

*Physical coefficients*—Basic, physical input; for instance, minutes of labor to do a job, not the dollar cost for labor.

*Primals*—Major divisions of the carcass, such as rounds, loins, chucks.

*Retail cuts*—Cuts sold by retailers and purchased by consumers.

*Subprimals*—Division of primals into smaller cuts, but not all the way to retail cuts; for instance, rounds to top round, bottom round, and knuckle.

*Systems*—Methods or channels of product flow, and locations of meat cutting, selected for analysis.

# FARM SIZE AND TRACTOR TECHNOLOGY

By Gordon E. Rodewald, Jr. and Raymond J. Folwell*

Technology creates changes in agriculture that all segments of the agricultural community need to consider to anticipate the resulting impacts. Objectives of the research were to project the size and number of farming operations in eastern Washington and to examine the implications for farm size of four-wheel-drive tractor technology. Based on Markov chain projections of farm size, enlargements will occur in farms over 1,000 acres. Use of four-wheel-drive tractors will pressure farming operations larger than 2,000 acres to enlarge further.

Keywords: Tractor technology, economics of farm size, Markov chains.

During 1960 to 1975, total farm output increased 25 percent; and extensive factor substitution occurred. The number of farms declined while their average size increased. The largest growth in agricultural inputs took place in chemicals, 176 percent. In contrast, mechanical power and machinery use rose 7 percent, labor decreased 42 percent, and land being farmed declined 4 percent.

The small gain in mechanical power and machinery relative to the large reduction in farm labor can be partly explained by comparing changes in the size of machinery. As late as 1966, only 5.5 percent of retail sales of farm wheel tractors were units having at least 100 power take-off (PTO) horsepower. By 1975, such large power units accounted for 46.7 percent of sales. The adoption of such technology varies by region, depending upon the type of farming.

Changing technology and farm size have significantly altered the agricultural economy, including the agribusiness industries which supply production inputs to agricultural producers. A problem faced by all segments of the agricultural economy is one of anticipating the effects of technological innovation.

The objectives of this article are: (1) to project the number and size of farming operations in a selected area to 1985; and (2) to examine the implications of changes in farm size for changes in tractor technology, particularly the new generation of four-wheel-drive tractors. We define a farming operation as the amount of land farmed by a single entity, such as an individual or a corporation. The land might be entirely or partly owned, rented, or leased.

## PROCEDURES

Markov chains (*6, 7*) were used to describe how the sizes of farm operations have changed over the last 10 years and to analyze how they may change over the next 10 years.[1] We assumed that the farming operations be grouped into various sizes (states) of operations according to acres. Further, the change in size of a farming operation through the various states is a stochastic process; the probability of moving from one state to another is a function of only the two states. To project number and sizes of farming operations, it was assumed that the same forces, economic and noneconomic, will be experienced during the projection period as were experienced during the base period from which the data were obtained.

The feasibility of the projected farm enlargements is appraised in terms of adoption of conventional and new tractor technology. We investigate the economic forces generated by the adoption of the large four-wheel-drive tractors, and the effects of these forces in changing farm sizes.

### Sample

Whitman County in eastern Washington was used as the study area. Parallel studies of Lincoln and Adams counties, not reported here, led to the same general conclusions about farm size trends and tractor technology as the Whitman County study (*4*). The major crops in the area are wheat, barley, peas, and lentils. The average rainfall ranges from 12 inches on the western side of Whitman County to about 25 inches on the eastern side. Peas and lentils are raised in eastern Whitman County where rainfall is sufficient.

The records of USDA's Agricultural Stabilization and Conservation Service (ASCS) county office provided the basic data on how farming operations had changed in the study area from 1965 to 1975. The potential new entrants into farming in the study area were assumed to be the males living on farms in the county. Using such a large number of potential entrants approaches the conditions of the perfectly competitive market model which approximately describes the production sector of agriculture (*10*).

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*Respectively, Agricultural Economist, in the National Economic Analysis Division, ERS, and stationed in Department of Agricultural Economics, Washington State University; and Associate Professor and Associate Agricultural Economist, Department of Agricultural Economics, Washington State University, Pullman, Washington.

[1] Italicized numbers in parentheses refer to items in References at the end of this article.

Estimated standard deviations of farm sizes were made with the 1969 Census of Agriculture and supplemental information from the ASCS county office. The standard deviation, mean, and total number of farm operators to be sampled were used to determine the sample size required to achieve a coefficient of variation of at least 7.6 percent in statistical estimates for farming operations of less than 2,000 acres. All farm operators in the county with 2,000 or more acres were added to the sample because the greatest adoption of the latest technology in farm machinery (four-wheel-drive tractors) has been observed on these operations. Thus, the overall coefficient of variation is less than 7.6 percent, but it was not possible to estimate the coefficient of variation for the entire population because the largest class interval in the Census of Agriculture was open-ended.

### Markov Chain Analysis

The ASCS data on farming operations in the county were used to develop the probability transition matrix (P) which described how farming operations changed over time among various acreage states:

| State | Size | Farms observed 1965 | Farms observed 1975 |
|---|---|---|---|
| | *Acres* | *Number* | |
| $S_0$ | 0 | 412 | 535 |
| $S_1$ | 1-99 | 176 | 75 |
| $S_2$ | 100-259 | 225 | 200 |
| $S_3$ | 260-499 | 452 | 375 |
| $S_4$ | 500-999 | 483 | 450 |
| $S_5$ | 1,000-1,999 | 269 | 400 |
| $S_6$ | 2,000-2,999 | 85 | 63 |
| $S_7$ | 3,000 and over | 11 | 15 |

Each element ($p_{ij}$) in the probability transition matrix (P) in table 1 is an estimate of the probability of a firm moving from one state to another. Because each row in the P matrix constitutes a probability vector, the premultiplication of the P matrix raised to the $n^{th}$ power by the row vector defining the states in the base period results in a row vector of the projected number of farming operations in each state in the $n^{th}$ future period. In general, $S^n = S^oP^n$ where $S^o$ refers to the base period vector and $S^n$ is the row vector of the future number and size of farming operations in the $n^{th}$ time period.

In this study, we examine only the situation where $n$ equals 2; that is, we project the 1965-75 transitions to 1985. We did not estimate an equilibrium solution of the process or an index of farm operation mobility in terms of changing size. There were no absorbing chains in this study. Estimating these various other facets arising from Markov chains would have implied unrealistic assumptions concerning future technology.
assumptions concerning future technology.

## PROJECTED FARM SIZE

Between 1975 and 1985, 22 percent of the farming operators are expected to enlarge their operations (table 2). Of these 471 operators, 62 are expected to be in the size groups larger than 2,000 acres. Over one-half (55 percent) of the total enlargements will be farming operations in the size groups of 1,000 acres or larger. Table 2 shows the average size of the farming operation of the sampled farms for each farm size category. The table does not show how many farmers will reduce the size of their operations during 1975-85. It is the number of enlarging farms that has implications for adopting new tractor technology.

## OPTIMUM MACHINERY SELECTION

One force causing farms to enlarge is excess capacity of farm power units. While the use of farm machinery increased only 7 percent during the decade studied, the number of farm tractors rating above 140 horsepower increased from less than 1 percent in 1970 to nearly 10 percent in 1974. All else equal, increases in tractor horsepower will result in excess capacity and frequently in a larger per unit cost (*9*).

Table 1.—Transitional probability matrix for farming operations in Whitman County, Washington, 1965 and 1975

| State | $S_0$ | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ | $S_7$ |
|---|---|---|---|---|---|---|---|---|
| $S_0$ | 0.8656 | — | 0.1292 | — | — | — | 0.0052 | — |
| $S_1$ | .6219 | .3731 | — | — | — | — | .0050 | — |
| $S_2$ | — | — | .5556 | .2222 | .1111 | .1111 | — | — |
| $S_3$ | .0553 | — | — | .7190 | .2212 | — | .0046 | — |
| $S_4$ | .1035 | — | .0518 | — | .6211 | .2070 | .0145 | .0021 |
| $S_5$ | — | — | — | — | .0929 | .8364 | .0706 | — |
| $S_6$ | — | — | — | — | — | .5882 | .3647 | .0471 |
| $S_7$ | — | — | — | — | — | — | .0909 | .9091 |

Table 2.—Farming operations expected to change farm size in Whitman County, Washington between 1975 and 1985

| Item | Farm size group (acres) | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | $S_0$ | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ | $S_7$ | |
| | 0 | 1-99 | 100-259 | 260-499 | 500-999 | 1,000-1,999 | 2,000-2,999 | 3,000+ | |
| | | | | | *Number* | | | | |
| Distribution of farming operations, 1985 | 551 | 49 | 200 | 271 | 399 | 555 | 70 | 20 | 2,115 |
| | | | | | *Acres* | | | | |
| Average size of farming operations, 1975 | 0 | 44 | 175 | 358 | 756 | 1,464 | 2,344 | 5,520 | -- |
| | | | | | *Number* | | | | |
| Total farming operations in each State as a result of enlargements | | | 7 | 57 | 149 | 196 | 54 | 8 | 471 |
| | | | | | *Percent* | | | | |
| Farming operations in each size group enlarging as a percentage of all farms enlarging | | | 1 | 12 | 32 | 42 | 11 | 2 | 100 |
| Farming operations enlarging as a percentage of farming operations, size group total | | | 4 | 21 | 37 | 35 | 77 | 40 | 22 |

Source: (*4*, tables 3, 5, and 7).

To determine the extent to which farm enlargements were made and will continue to be made possible by the excess capacity, we defined the maximum acreage that can be handled by one person within a given time using both conventional and four-wheel-drive tractor technology. The time constraint was twofold: (1) the constraint on field time available for completing a specific tillage operation; and (2) the total field time available during a crop season. The maximum acreage is determined in the following set of equations:

$$USS_i = FS*T_i/(AS*IS_i*FE_i/825) \quad (1)$$

$$D_i = DI_i + WGT_i*S \quad (2)$$

$$USS_i \leqslant H_j \quad (3)$$

$$\sum_i^n USS_i \leqslant TH \quad (4)$$

$$D_i \leqslant TL_k \quad (5)$$

Where:

$USS_i$ is the hours required to complete the $i^{th}$ tillage operation on a given farm size;

825 equals (square feet in 1 acre ÷ feet in 1 mile) (100) = (43,560 ÷ 5,280) (100): serves to convert a linear distance into an area;

TH is the total number of hours available for field work during the crop production season;

$H_j$ is the number of hours available for field work in the $j^{th}$ time period ($j = 1, 2, \ldots, m$);

FS is defined as the farm size in acres of cropland in rotation;

$T_i$ is the number of times the $i^{th}$ implement is pulled over the cropland;

AS is the average speed of the tractor in miles per hour;

$IS_i$ is the width in feet of the $i^{th}$ implement being pulled;

$FE_i$ is the field efficiency of the $i^{th}$ implement in percent;

$TL_k$ is the pounds of drawbar pull available in the $k^{th}$ gear for the tractor ($k = 1, 2, \ldots, r$);

$D_i$ is the total draft requirements of the $i^{th}$ implement, composed of the forces parallel to the direction of travel including soil resistance and the component of implement and tractor weight parallel to the slope;

$n$ is the number of different tillage operations required in the crop rotation scheme;

$DI_i$ is the component of total draft, composed of the soil and crop resistance of implement $i$;

$WGT_i$ is the sum of the weights of implement $i$ and the tractor being used;

S is the sine of slope angle $a$ used to compute the component of implement and tractor weight forces parallel to the slope.

Equation (1) specifies the number of hours required to complete the $i^{th}$ tillage operation. Equation (2) determines the draft requirement for the $i^{th}$ tillage implement. The equation for draft requirements was developed from information given by Hunt (*5*, pp. 24-46). The restrictions imposed on equation (1) by inequality (3) limit the number of hours available to complete the $i^{th}$ tillage operation to not more than the hours of field time available during the $j^{th}$ time period. Inequality (4) limits the total hourly requirements for all tillage operations in the crop rotation to not more than the total hours of field time available during the cropping season. Inequality (5) restricts the draft requirements for the $i^{th}$ implement to not more than the amount of tractor power available.

The coefficients for equations (1) and (2) were developed from engineering data. Draft requirements for each implement were developed using information contained in the 1975 *Yearbook of Agricultural Engineers* (*1*). The information for pounds of drawbar pull available by tractor size was taken from the Nebraska test data modified as suggested by Hunt (*5*, pp. 29-30).

The calculations of the costs of owning and operating each item on the machinery complement necessary for various types of crop rotations were:

$$\text{Annual depreciation} = \frac{\text{New cost minus salvage value}}{\text{Years of operation}} \tag{6}$$

$$\text{Average annual investment cost} = \left(\frac{\text{New cost plus salvage}}{2}\right)(\text{Interest rate}) \tag{7}$$

$$\text{Average annual property tax} = \left(\frac{\text{New cost plus salvage}}{2}\right)(\text{Average assessment})(\text{Tax rate}) \tag{8}$$

$$\text{Average annual insurance cost} = \left(\frac{\text{New cost plus salvage}}{2}\right)(\text{Cost of insurance}) \tag{9}$$

$$\text{Annual storage cost} = (\text{Square feet of storage required})(\text{Cost of storage foot}) \tag{10}$$

$$\text{Hourly implement repair and maintenance costs} = \frac{(\text{New cost})(\text{Implement repair factor})}{\text{Total normal operating hours}} \tag{11}$$

$$\text{Hourly implement preparation cost} = \frac{(\text{New cost})(\text{Implement preparation factor})}{\text{Annual operating hours}} \tag{12}$$

$$\text{Fuel cost per acre} = \frac{(\text{Average fuel consumption/hours})(\text{Fuel cost/gallon})}{\text{Acres per hour}} \tag{13}$$

Annual costs calculated in equations (6) through (10) were converted to an hourly rate by dividing by annual hours of use. The hourly rate was used to compute the cost per acre for each implement used in the rotation. The hourly implement repair, maintenance, and preparation costs factors used in equations (11) and (12) were taken from a study by Oehlschlaeger and Whittlesey (*8*). The factors relate to maintenance and repair over the entire useful life of the machine. The preparation factor relates to preparing the tractor for field service. For motorized equipment, both equations (11) and (12) were used; for nonmotorized equipment, only equation (11) was necessary.

Fuel consumption and fuel cost per acre were functions of field slope, maximum fuel requirements of the engine, and power required for each task. The average fuel consumption per hour used in equation (13) was determined by calculating the portion of time the tractor spends at each slope times the portion of maxi-

mum drawbar pull being used (the draft required divided by the drawbar pull) times the maximum fuel consumption. The relationship was (*10*):

$$\text{Average fuel consumption} = (\text{F}) \sum_{i}^{k} \text{R}_i \text{P}_i \ (1.15) \qquad (14)$$

Where:

F is the maximum fuel consumption per hour;

R is the portion of time the tractor spends at a given slope in a representative field;

$P_i$ is the portion of the maximum available drawbar pull actually used (never less than 0.5);

The factor 1.15 is suggested by Hunt to adjust the fuel consumption to reflect the less than ideal conditions that exist in the Nebraska tests (*5*, p. 31).

The estimated changes in machinery inventory and operating costs of farming operations moving from an assumed size of 629 acres to 1,304 acres; from 1,206 acres to 1,347 acres; or from 2,066 acres to 3,587 acres, are shown in table 3 for an operation with a winter wheat-pea-fallow rotation.[2] The illustration is in terms of (1) a common size of conventional crawler tractor; and (2) a commonly purchased four-wheel-drive tractor. The data in table 3 compare the 90 drawbar horsepower (dbhp) crawler tractor with a 228 dbhp four-wheel-drive tractor for selected enlargements in the farming operation.

Per acre costs are less if the 90 dbhp tractor is kept as opposed to obtaining the large tractor when the farming operation increases from 629 to 1,304 acres and from 1,206 to 2,347 acres. This results from the lumpiness of machinery inputs.

The greatest advantage in using the large tractor is on the larger acreages. If acreage is increased from 2,066 to 3,587 acres, economies can be gained in both labor and machinery using the larger four-wheel-drive tractor compared with the conventional 90 dbhp tractor. One tractor with its associated equipment is saved, resulting in the labor savings of one person for a total of 980 hours with the 228 dbhp tractor compared with the 90 dbhp tractor. The machinery costs excluding labor are lower by $3.54 per acre, indicating substantial economies in both labor and machinery operating costs for the larger four-wheel-drive tractor compared with the conventional crawler tractor.

[2] These are the average beginning and ending sizes of the sampled farming operations for Whitman County.

## OPTIMUM MACHINERY SELECTION AND PROJECTED FARM SIZE

The effects of enlargement in farming operations on the machinery investment and operational costs for the farming operations illustrated in table 3 are shown in table 4. The additional cost of owning and operating the larger tractor on the smaller acreages is much higher per acre than that of the smaller tractor. The enlargement can be made on the largest farm size with the large 228 dbhp four-wheel-drive tractor at a lower machinery cost per acre ($3.54) and a lower total investment ($35,174.00). In addition. the change can be made without additional labor. Savings are also available in other types of farming operations in the study area. As with the wheat-pea rotation, the greater savings are always at the larger sizes of farming operations.

Table 5 shows machinery operating costs per acre by farm and tractor size for the winter wheat-fallow area of eastern Washington, a rotation typical of most farming operations there, and in northern Oregon. If an operator acquires a large four-wheel-drive tractor (225 dbhp and over) for any farm size within the economic feasibility range of the conventional crawler tractor, the per acre machinery cost will increase. This cost can only be reduced by spreading the fixed costs over a larger acreage, increasing the likelihood that farming operations will enlarge to reduce cost to the preacquisition cost. The breaking point between the least-cost machinery costs for the conventional crawler type tractor and the four-wheel drive tractor is a farming operation of approximately 2,000 acres.

## IMPLICATIONS

The projections of sizes of farming operations by individual counties via Markov chains indicated that the major enlargements in the farming operations would occur primarily in the group over 1,000 acres, following a trend that existed during 1966-75. The number of farming operations larger than 2,000 acres in the study area is expected to increase by 54 operators between 1975 and 1985.

The projected increases in the sizes of farming operations above 2,000 acres will result partially from the continued economic pressure caused by introduction of the new four-wheel-drive technology. To use a four-wheel-drive tractor economically, farming operations must contain at least 2,000 acres. Per acre machinery costs for both conventional and four-wheel-drive tractors show that the farm operator using the four-wheel-drive technology and anticipating an enlargement from 2,000 to 3,600 acres will incur a smaller cost and be able to enlarge his farming operation with existing labor. The farmer with a conventional tractor may not be able to do so.

Large retail sales of large power units imply that con-

Table 3.—Implements, labor, and machinery cost per acre by farm and tractor size for Eastern Washington farms with winter wheat-pea-fallow rotation

| Item | Unit | 90 dbhp crawler tractor | | | | | | 228 dbhp 4-wheel-drive tractor | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ending farming operation size group | Acres | 1,000-1,999 | | 2,000-2,999 | | 3,000 + | | 1,000-1,999 | | 2,000-2,999 | | 3,000 + | |
| Addition to farming operation | do. | 675 | | 1,142 | | 1,520 | | 675 | | 1,142 | | 1,520 | |
| | | Beginning | Ending | Beginning | Ending | Beginning | Ending | Beginning | Ending | Beginning | Ending | Beginning | Ending |
| Power units | Number | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 2 |
| Farm size | Acres | 629 | 1,304 | 1,206 | 2,347 | 2,066 | 3,587 | 629 | 1,304 | 1,206 | 2,347 | 2,066 | 3,587 |
| Moldboard plow | Bottoms | 6 | 11 | 11 | 20 | 18 | 30 | 4 | 7 | 7 | 12 | 12 | 20 |
| Tandem disk | Feet | 14 | 28 | 24 | 48 | 40 | 72 | 10 | 16 | 16 | 28 | 28 | 48 |
| Spiketooth harrow | do. | 20 | 35 | 30 | 60 | 60 | 90 | 20 | 20 | 20 | 40 | 40 | 60 |
| Disk drill | do. | 10 | 12 | 10 | 20 | 20 | 30 | 10 | 10 | 10 | 20 | 20 | 20 |
| Rodweeder | do. | 10 | 10 | 10 | 20 | 20 | 30 | 10 | 10 | 10 | 20 | 20 | 20 |
| Springtooth harrow | do. | 28 | 52 | 48 | 88 | 80 | 132 | 16 | 32 | 32 | 56 | 48 | 88 |
| Unitized weeder | do. | 30 | 30 | 30 | 60 | 60 | 90 | 30 | 30 | 30 | 60 | 60 | 60 |
| Fertilizer applicator | do. | 30 | 30 | 30 | 60 | 60 | 90 | 30 | 30 | 30 | 60 | 60 | 60 |
| Labor total | Hours | 775 | 1,097 | 1,069 | 2,016 | 2,010 | 3,024 | 581 | 909 | 847 | 1,648 | 1,530 | 2,044 |
| Labor/acre | do. | 1.11 | .78 | .82 | .84 | .91 | .84 | .83 | .65 | .65 | .69 | .70 | .57 |
| Machinery cost/acre | Dollars | 34.98 | 23.61 | 24.91 | 25.95 | 26.95 | 25.95 | 40.24 | 25.93 | 27.10 | 28.03 | 29.82 | 22.41 |
| Total cost/acre | do. | 43.00 | 29.40 | 31.05 | 32.16 | 33.68 | 32.16 | 46.06 | 30.63 | 31.86 | 32.97 | 34.87 | 26.57 |



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Table 4.—Machinery costs and labor requirements for move to larger farming operation by farm and tractor size, eastern Washington farms with winter wheat-pea-fallow rotation

| Item | Unit | 90 dbhp crawler tractor | | | | | | 228 dbhp 4-wheel-drive tractor | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ending farm operation size group | Acres | 1,000-1,999 | | 2,000-2,999 | | 3,000 + | | 1,000-1,999 | | 2,000-2,999 | | 3,000 + | |
| Addition to farming operation | do. | 675 | | 1,142 | | 1,520 | | 675 | | 1,142 | | 1,520 | |
| | | Beginning | Ending | Beginning | Ending | Beginning | Ending | Beginning | Ending | Beginning | Ending | Beginning | Ending |
| Power units | Number | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 2 |
| Farm size | Acres | 629 | 1,304 | 1,206 | 2,347 | 2,066 | 3,587 | 629 | 1,304 | 1,206 | 2,347 | 2,066 | 3,587 |
| Moldboard plow | Dollars | 3,890 | 7,472 | 7,472 | 13,648 | 12,520 | 20,472 | 2,716 | 5,198 | 5,198 | 7,780 | 7,780 | 13,648 |
| Tandem disk | do. | 3,334 | 6,667 | 6,052 | 12,104 | 9,529 | 18,156 | 2,743 | 4,102 | 4,102 | 6,667 | 6,667 | 12,103 |
| Spiketooth harrow | do. | 405 | 709 | 608 | 1,216 | 1,216 | 1,824 | 405 | 405 | 405 | 810 | 810 | 810 |
| Disk drill | do. | 2,938 | 3,244 | 2,938 | 5,288 | 5,288 | 7,932 | 2,938 | 2,938 | 2,938 | 5,876 | 5,876 | 5,876 |
| Rodweeder | do. | 904 | 904 | 904 | 1,808 | 1,808 | 2,712 | 904 | 904 | 904 | 1,808 | 1,808 | 1,808 |
| Springtooth harrow | do. | 1,449 | 2,691 | 2,484 | 4,554 | 4,140 | 6,831 | 828 | 1,656 | 1,656 | 2,898 | 2,484 | 2,277 |
| Unitized weeder | do. | 5,409 | 5,409 | 5,409 | 10,818 | 10,818 | 16,227 | 5,409 | 5,409 | 5,409 | 10,818 | 10,818 | 10,818 |
| Tractor | do. | 40,500 | 40,500 | 40,500 | 81,000 | 81,000 | 121,500 | 56,570 | 56,570 | 56,570 | 113,140 | 113,140 | 113,140 |
| Additional cost | do. | | 8,767 | | 64,069 | | 69,335 | | 4,669 | | 72,615 | | 11,097 |
| Total equipment cost | do. | 58,829 | 67,596 | 66,367 | 130,436 | 126,319 | 195,654 | 72,513 | 77,182 | 77,182 | 149,797 | 149,383 | 160,480 |
| Number of workers | Number | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 2 |
| Change in investment level of large tractor system | Dollars | | | | | | | | 9,586 | | 19,361 | | -35,174 |

Table 5.—Machinery costs per acre by tractor and farm size, eastern Washington farms with winter wheat-fallow rotation, 12-16 inch rainfall area

| Farming operation size (acres) | Cost per acre by tractor size (dbhp) | | | | | |
|---|---|---|---|---|---|---|
| | Conventional crawler | | | 4-wheel drive | | |
| | 70 | 90 | 125 | 185 | 225 | 262 |
| | | | Dollars | | | |
| 500 | 43.48 | 50.41 | 54.60 | 46.61 | 55.82 | 55.02 |
| 700 | 35.44 | 40.75 | 43.55 | 36.84 | 44.28 | 43.38 |
| 900 | 30.07 | 34.34 | 36.98 | 31.33 | 37.58 | 36.60 |
| 1,100 | 26.70 | 30.20 | 32.40 | 27.63 | 33.19 | 32.22 |
| 1,300 | 24.52 | 27.62 | 28.80 | 25.07 | 30.16 | 29.08 |
| 1,500 | 22.38 | 25.10 | 26.02 | 23.17 | 27.90 | 26.75 |
| 1,700 | 21.26 | 23.50 | 24.38 | 21.70 | 26.14 | 24.97 |
| 1,900 | 19.78 | 21.77 | 22.46 | 20.54 | 24.60 | 23.56 |
| 2,000 | * | 21.50 | 21.85 | 19.72 | 23.97 | 22.97 |
| 2,100 | | 21.07 | 21.29 | 19.43 | 23.45 | 22.02 |
| 2,300 | | 20.30 | 19.92 | 18.59 | 22.27 | 21.27 |
| 2,500 | | 19.70 | 19.44 | 17.72 | 21.44 | 20.45 |
| 2,600 | | * | 19.30 | 17.44 | 21.42 | 20.08 |
| 2,700 | | | 18.57 | 17.15 | 20.81 | 19.63 |
| 2,900 | | | * | 16.62 | 20.11 | 18.92 |
| 3,100 | | | | 16.23 | 19.49 | 18.68 |
| 3,300 | | | | 15.79 | 18.58 | 17.91 |
| 3,500 | | | | 16.03 | 18.09 | 17.44 |
| 3,700 | | | | 15.43 | 17.73 | 16.98 |
| 3,900 | | | | 14.47 | 17.00 | 16.25 |

*Beyond this acreage, the time constraint for one of the tillage operations is violated.

tinued economic forces will cause further increases in sizes of farming operations. The economic force mainly involves spreading the large fixed capital investment costs over larger acreages; that is, achieving lower average fixed costs.

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# ATTEMPTS TO CONTROL ACCESS TO THE LITERATURE OF AGRICULTURAL ECONOMICS

By Gerald R. Ogden

Computer applications are the most recent advance in the man-machine relationship in agriculture. In the past decade, these applications have grown phenomenally, especially in the areas of research, development, and experimentation. The use of the computer has led to a corresponding growth in the publication of literature reporting findings of research accomplished. Attempts to control this literature through secondary services are discussed. A brief history of influences determining the output of agricultural economics literature is presented, and early efforts to establish bibliographic control over these publications are reviewed. More recently, however, publication of research findings has far exceeded attempts over their control, and this has become a problem. Results of much research are not reaching potential users. Thus, it becomes increasingly difficult to justify funding of projects that do not find practical application. This problem may partially be overcome by supporting efforts to provide secondary services. Ultimately, it will require greater attention to and funding for computerized bibliographic control of literature.

Keywords: Agricultural economics, computer, literature, bibliography.

Computer applications to agriculture cover a wide spectrum of subject areas and touch upon many disciplines. Few areas are so underutilized, so misunderstood, and so little noticed, however, as the application of the computer to literature retrieval. Investigators should know and will find value in understanding how this literature is captured, controlled, and accessed, for not only will they obtain a clue to a valuable source of information, but they will learn what type of literature can be accessed.

My purpose is to focus on the problems of literature retrieval by computerized techniques in the field of agricultural economics. The experiences involved in the preparation and maintenance of a computerized bibliographic service in this field are not unique. To the contrary, such problems are widespread. But even in the early stages of development of a discipline, a lack of control over the literature emerges. This fact will be illustrated through a historical sketch of the beginnings and growth of the agricultural economics profession. I then examine the impact the computer has had on the profession, relate briefly the trends occurring in the types of studies conducted by economists, and demonstrate how these trends have influenced literature control. Next, efforts exerted to control the literature will be summarized. I will conclude by suggesting that because bibliographic services, in general, have such a low priority in relation to other aspects of research, it is improbable that complete secondary control of publications will be achieved in agricultural economics. And this likelihood, I fear, will act detrimentally to the development of research.

## BEGINNINGS AND GROWTH OF THE PROFESSION

The profession of agricultural economics is a child of the 20th century, although its origins can be traced to the waning years of the 19th century. According to Henry C. Taylor, in 1897 Liberty Hyde Bailey of Cornell University and 10 other educators gathered at a meeting of the American Economic Association at Johns Hopkins University to form a seminar on the question, "Is there a distinct agricultural question?" (*21*)[1] The report of this meeting, and thus one of the original publications in agricultural economics, was subsequently published by the Association in its Economic Studies Series (*4*, pp. 52-67). Further studies followed. In 1903 a group met at a joint session of Section 1 of the Association for the Advancement of Science and the Society for the Promotion of Agricultural Science in St. Louis, Missouri. It was the 20th annual meeting of the American Economic Association (December 1907) that served as the genesis of the profession, however. The first "round table" was held at this gathering, and as a way of endorsing the new field, the American Economic Association published the discussions in its proceedings (*2*, pp. 59-82). From this date forward the field of agricultural economics, and its literature, began to expand.

It took several years before formal organization was accomplished and research papers were published under the auspices of an association. In the meantime, the American Economics Association continued to harbor an interest in the subject, and periodically, to 1912, sponsored sessions at its annual meetings. A parallel development occurred at the same time. Professors of farm management at various universities began independent studies in economics, and in 1910 several of these researchers joined together to form the American Farm Management Association.

There were other organizations interested in the subject of agricultural economics, but from 1913 to 1916,

[1] Italicized numbers in parentheses refer to items in References at the end of this article.

the principal players in this drama were the Farm Management Association and the National Conference on Marketing and Farm Credits. In 1916 these two bodies combined and formed a new organization, the National Association of Agricultural Economics. But this was a temporary union. By 1919 the National Conference on Marketing and Farm Credits withdrew, and the National Association of Agricultural Economists and the American Farm Management Association grouped to form the American Farm Economics Association, the predecessor to the American Agricultural Economics Association. In the same year (1919), the first issue of the *Journal of Farm Economics* was issued.

Three observable facts emerge from a retrospective look over the 20-year period educators and researchers spent legitimizing the field of agricultural economics. First, persons from an array of disciplines, such as agronomy, farm management, animal husbandry, and general economics, among others, became interested in the application of economics to agricultural problems. Their membership in the Association thus determined, even at the beginning, that the field would be interdisciplinary in nature. As a consequence of the multisubject area orientation, the literature output on the subject of agricultural economics has been predestined to appear in virtually hundreds of publications.

For scholars, bibliographers, and librarians, the uncertainty associated with irregular publication (especially prior to 1919) and the appearance of articles in a wide variety of publications, many of which were ephemeral, led to difficulty in capturing information. The problem was further compounded by the interdisciplinary nature of agricultural economics. In brief, it became a problem not only of being aware of, but then locating materials. Also, subjective judgment influenced the type of literature included in various bibliographic lists. Needless to say, these two problems are with us today. Now, however, they are multiplied many times over as a result of an increase in the output of publications and of subject areas covered by agricultural economics research.

Librarians made early attempts to control the literature. The most outstanding example was a series of bibliographies compiled by Mary G. Lacy of USDA's Bureau of Agricultural Economics. Comprised of a limited number of pages, they were, as S. von Frauendorfer, founder and editor of the World Agricultural Economics and Rural Sociology Abstracts, states, modest documents (*12*, p. 99). But they were prestigious, for they are the first of such publications of which we are aware. The bibliographies became a regular publication, *Agricultural Economics Literature*, in 1927, testifying that the literature of agricultural economics was growing both in numbers and stature. This publication was replaced in 1942 when the National Agricultural Library assumed centralized control of all library operations within the Department and initiated publication of its own bibliography.

Lacy also compiled other lists of references, especially on the literature of statistics and farm management. Few similar compilations appeared during World War II, however, as the rigors of war restricted the library's resources. In the postwar period, bibliographic services were taken up on an international scale. Meanwhile emphasis on the control of agricultural economics literature in the United States languished.

## NEW IMPACTS

Two post-World War II developments, a significant increase in the output of literature in the social sciences and the adaption of the computer for civilian use, challenged scholars and researchers. The number of publications produced worldwide expanded so rapidly as to defy retrieval through traditional secondary access points, such as bibliographies, book reviews, and book notes in journals. The introduction of the computer for civilian use compounded this problem. Because much of the computational work done by hand in economics was removed, research efforts expanded. This allowed researchers more time to pursue additional projects, and the output of literature increased substantially.

In a recent survey conducted to establish the size, growth, and composition of social science literature, investigators determined that between 1820 and 1930 the number of current serials increased from 22 to approximately 1,000 (993). There followed but a slight increase in serial growth during the early depression years of the thirties. But, between 1935 and 1970, the publication rate exploded: it increased from 1,134 to 3,490, or over 300 percent (*16*, p. 129). Through use of a conversion factor of 36 articles per title, the authors estimated that the number of articles published in 1970 equaled about 140,000, while the number of monographs totaled approximately 130,000 (*16*, p. 126).

Over the same timespan there occurred a corresponding increase in efforts to establish bibliographic control of the literature. In fact, such emphasis was placed upon this aspect of publishing that secondary services, historiographies, book lists, descriptive abstracts, and the like, increased considerably faster than did the literature. For example, the ratio of primary journals devoted exclusively to secondary services, estimated at 42:1 in 1920, declined to 35:1 in 1940, 19:1 in 1960, and 15:1 in 1970. American scholars and researchers benefited appreciably from the increased services, for of all the primary journals published, nearly 31 percent originated in the United States. But the access problem was not solved. The ratio of review articles published in social science journals to primary articles totaled only 1:133 (in contrast to the physical sciences where the ratio was 1:45) in 1974 (*16*, p. 143). Also, the exceedingly large growth in secondary services output was itself beginning to defy impositions of control.

The advent of the computer added appreciably to the

bibliographic control dilemma. In retrospect, Ludwig M. Eisgruber recalls that, following World War II, economists became interested in the "analytical potential of mathematical programming models and in their various special forms, in particular linear programing and transportation models" (*10*, p. 930). Such applications were delayed, however, until 1949 when mathematicians T. C. Koopmans, George B. Dantzig, and others developed linear programing techniques (*15*, p. 74; *6*, pp. 299ff).

As might be expected, governmental units and universities formed the vanguard in the use of linear programing for research, although it took the better part of a decade before its practical application became widespread. In 1950 only one agricultural economics department in the United States used linear programing in research work, no courses were offered on the subject, and no use was made of it in adult education. Then, beginning with Frederick V. Waugh's pathfinding article, "The Minimum Cost of Dairy Feed: An Application of Linear Programming" (*6*, pp. 299-310) in August 1951, a number of studies, 50 to be exact, appeared over the next decade (*10*, pp. 393-400). These, too, spurred interest. Subsequently, throughout the sixties, various symposiums, sponsored by International Business Machines, were held, and a number of conferences initiated by government agencies and universities. The agricultural press also took an interest, and a substantial amount of literature was generated on the subject of linear programing. New intellectual approaches to computer utilization resulted, and dynamic programming, simulation, management games, and automated budgeting came into being. Increased application stimulated output, and the published results added to the mounting body of literature.

A survey conducted for 1961-63 demonstrated the magnitude of the problem. Agricultural economists through this period published an average of 2,500 publications a year. Of this number, 51 percent were classified as research and professional papers; 44 percent, as informational or popular literature; and 5 percent, as miscellaneous. Title dispersement was large. Some 577 articles, for example, appeared in 119 research periodicals, and 1,815 articles, in 347 information or trade periodicals. Nearly 48 percent of the publications were monographs, either in series or singles (*17*, p. 59; *1*, p. 9).

The rate at which various secondary services indexed or abstracted this output was, in contrast, far from complete. Only 45 percent of publications on agricultural economics were included in the 8 major services surveyed. And, as might be expected, the publications most readily available to the researchers and to which they might have already been exposed—such as the leading journals and more familiar government documents—were most frequently indexed. Articles appearing in research and professional journals were indexed once or more, 80.5 percent of the time. Research monographs in series enjoyed a 72.1 percent coverage, and U.S. Government documents were indexed 65.3 percent of the time from 1961 to 1963. Publications emanating from universities and colleges, totaling more than one-half (53.76 percent) of all economics literature output, suffered appreciably from lack of control. Secondary services included these documents in their files less than one-half the time (*17*, pp. 77, 29, 40; *1*, p. 10). As the title dispersement expanded and as literature became more esoteric, the risk increased that items would not be included in secondary sources. Articles appearing in trade or information periodicals, information reports or circulars not in series, unnumbered talks, papers, and research reports were rarely indexed or abstracted.

Duplication also occurs as secondary services often choose identical titles to include in their files, especially of journal articles and Government publications in series. Additional items chosen appear to be randomly selected and less frequently are duplicated. There is seldom demonstrated, therefore, a marked degree of consistency in indexing and abstracting. Researchers thus may be forced into the awkward position of searching two or more secondary sources to obtain needed information, and even then, there is no guarantee of the completeness of the results.

Certain farsighted persons within the American Agricultural Economics Association early recognized that agricultural economists needed indepth exposure to the literature in their field, and that at the same time they required emancipation from the burden of spending hours of research time searching for information. To satisfy these requirements, a group of individuals, headed by Harry Trelogan, then Administrator of USDA's Statistical Reporting Service, began in the spring of 1961 to organize an effort to establish a secondary service. Its mission, they envisioned, would be to collect, document, and disseminate information on literature produced by agricultural economists in the United States and Canada. It took nearly 9 years to achieve this goal. Standing committees were appointed, such as the Committee on Retrieval of Agricultural Economics Literature; unsuccessful efforts were extended to gain support from the National Science Foundation; conferences were held; and a study was commissioned to establish the necessity and feasibility of the proposed project. These efforts bore fruit. In January 1970, an American Agricultural Economics Documentation Center was established as a cooperative venture between the American Agricultural Economics Association and various agencies within the U.S. Department of Agriculture.

## CURRENT TRENDS AND OUTPUT

The Documentation Center was established none too soon, for agricultural economists continued to expand the subject areas for research, and the use of the computer became commonplace. These researchers, of course, maintained an interest in livestock feeding opera-

tions and farm accounting; areas in which the computer was originally applied in agricultural economics. As a result, models became increasingly sophisticated, included the spectrum of livestock types, and, perhaps more importantly, found some application in farm management situations.

Irrespective of these efforts, the emphasis in agricultural economics remains one of research, development, and experimentation. Increasingly, agricultural economists have drifted away from the traditional areas of study, such as production, marketing, and farm accounting, to meet new challenges. A random sample of publications received by the Documentation Center reveals, for instance, that researchers are considering such matters as retirement planning for farm families, estate management problems, the labor market for agricultural graduates in India, and budget allocation models for large hierarchical research and development organizations (*14*; *10*, pp. 177-186; *20*; *5*, pp. 59-70). Other agricultural economists using input-output analysis, examine the economic impacts of resource use, particularly as they relate to changing agricultural land uses. Input-output analysis is also applied to study the impacts of urban growth on local government costs and revenues (*22*, *19*). Still other researchers study problems resulting from the open space concept in land use; they seek out the impacts of environmental policies and programs; and they examine questions relating to transportation and the training of transportation specialists at the college level (7, pp. 23-34; *13*, pp. 71-77; *3*). Also it is not uncommon to find, among the various reports received, feasibility studies relating to the locating of processing plants for agricultural products (*8*).

No empirical evidence exists to support the claim that there is a direct correlation between the extension of agricultural economics research and an increase in the number of publications produced. Similarly, no existing evidence draws a direct correlation between an increased use of the computer and a rise in publication output. On the other hand, such a correlation does appear likely, as a recent Economic Research Service inhouse report indicates. That study reveals that the Agricultural Economics Documentation Center is currently receiving over 5,100 documents per year for input into the data file. The author of the report concludes, however, that this is but a portion of the publications extant on the subject of agricultural economics; that there exists somewhere beyond our immediate capability to capture as many as 12,600 such publications (*18*). If so, then in a period of a decade and a half, or since 1961-63, publication output has increased fivefold.

Monographs, as in the earlier period, still comprise the bulk of this output. But title dispersement has also increased to an unmarked degree. This fact, coupled with the expanding publication population, has increased the burden of providing secondary services, which, in turn, seriously affects decisionmaking processes concerned with setting priorities for resource use. Experience has taught us, for example, that bibliographic services generally suffer from a low priority within a management system. Progressive managers will admit to their value, and they usually support projects, if only with moderate funding. But given the circumstance when an information explosion takes place, as now, serious questions are raised regarding the allocation of resources. The foremost considerations are: to what extent is the data file used? How much is enough; will as many of the materials as are practically available be put into the file, or must limitations on input be set? And, if input is limited, who will choose the materials to be entered, and what will comprise the selection criteria?

These are legitimate questions and must be posed by managers. They result, however, not solely from current conditions but from the fact that satisfactory answers to unexplored questions were not pursued with sufficient vigor before the initiation of the various projects. Planners of secondary services initiated a decade or more ago could not have foretold how dramatically the output of publications would rise. Yet it remains a fact that, today, published materials do exist *en masse*, and they remain virtually uncontrollable with current resources. How do managers, then, approach this problem?

One way is by discriminating in selecting information to be entered into the system, and by changing the emphasis of the projects by encouraging increased user participation. Selective input results from choosing materials from publications found, by study, to consistently contain pertinent information of interest to users. Littleton discovered, for instance, that a bibliographical service in agricultural economics "can cover about 90 percent of the periodical literature by indexing and abstracting about 50 percent of the periodicals in which agricultural economists publish" (*17*, p. 59). Once these periodicals are identified, and studies completed to determine the allocation requirements for their capture and conversion into machine-readable form, a major portion of the resource allocation problem can be resolved.

A more fundamental problem exists with realining attitudes and emphasis directed toward the operation of secondary services. With the opportunity of establishing computerized information files, planners all too frequently stress input and maintenance functions while suppressing or ignoring users' needs. End users are seldom educated in the existence, purposes, benefits and limitations, or contents of information systems. Nor are they provided opportunities to interface interactively with files to any degree. Generally these activities are relegated to an intermediary, a terminal operator. User intimacy with systems is, therefore, rarely established. It is not uncommon to find secondary services underutilized for this reason. And this malady can be traced directly to the lack of emphasis given to the education of users.

## CONCLUSION

Literature retrieval is a necessary function of research. In the past, when the output of research articles and monographs by agricultural economists was modest, access to the literature was gained through the "old buddy" system, or by manually searching a pertinent, but a limited number of publications. In recent years manual searching for bibliographic references has become increasingly time consuming and costly, and it proves of limited value because of the veritable explosion that has occurred in the publication of agricultural economics literature. To overcome these problems, various organizations adopted computer techniques to establish bibliographic control over these documents, envisioning as they did so that, by centralizing secondary services and increasing the speed of the retrieval process, the needs of researchers would be more fully met.

In theory, computerized bibliographical services have met the test. Online literature retrieval of surrogate documentation of agricultural economics literature has proven rapid, cost-effective, and reliable. Conversely, programs designed to maintain these systems are beset with difficulties, thus reducing the effectiveness of the services. Because of the population size of the literature extant, information systems seldom contain complete coverage of current publications while limited resources restrict input still further. And, for the reason that few efforts have been extended to educate users in interfacing with information systems, many files remain underutilized. Maximum utilization of information files as an aid in research, however, remains the *raison d'etre* of every system. Emphasis must be placed, therefore, on user education, since this will result in increased user demand. In turn, increased demand prompts the allocation of increased resources, and a broadened, increasingly sophisticated information system will result.

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## IN EARLIER ISSUES

Statisticians are constantly trying to make their methods more precise, not only because of their scientific interest but also to meet the ever-increasing load which modern society throws upon statistical measurement.

Emerson M. Brooks
Volume I, Number 2, p. 37
April 1949

How complete is a "complete" census? About the only answer is "As nearly complete as the agency taking the census can make it with the resources and ingenuity at its disposal."

Charles F. Sarle
Volume I, Number 2, p. 62
April 1949

# RESEARCH REVIEW

## IN THIS ISSUE

"No single instrument of youthful education has such mighty power, both as regards domestic economy and politics, and in the arts, as the study of arithmetic," says Plato in Book V of the *Laws*. "Above all, arithmetic stirs up him who is by nature sleepy and dull, and makes him quick to learn, retentive, shrewd, and aided by art divine he makes progress quite beyond his natural powers." Plato never said that the arithmetic methods used had to be particularly complicated. Presumably he would concur that relatively simple procedures are capable of stirring us to make progress both as regards domestic economy and politics.

Two of the articles in this issue, the second and the third, depend on a traditional arithmetical research technique known as budgeting. Authors of one article use budgets to show that a relatively new distribution system for fabricating and retailing beef is not as cost effective as some have thought it to be. The new handling system is familiarly called "boxed beef" because the packer prepares smaller cuts at a central place and ships them to the retailer in boxes. The second example of budgeting shows that the new, powerful, four-wheel-drive tractors frequently are purchased for use on farms which are too small for the tractors to be cost effective. Both budgeting examples demonstrate that simple arithmetical procedures can be powerful instruments for upsetting popular beliefs.

Relatively simple arithmetic aspects of probability and chance are used in the first and third articles. In the first, the authors, through normal distribution and probability, estimate the variations in Government payments to farmers that might be expected under current disaster insurance programs. Payments made in 1974 were found to be unexpectedly large while those in 1975 came closer to expectations. The second example of probability analysis involves random moves that individuals might make among feasible alternatives. The method, known as a Markov Chain, is applied to growth in farm size. It shows that, while farms are expected to grow, the enlargements are not occurring fast enough to absorb efficiently the number of large tractors being sold to farmers.

The fourth article elicits a disquieting and paradoxical conclusion: Even those of us who dislike arithmetic and large-scale, high-speed computers, who only want to read agricultural economics literature written in plain English, must turn more and more to computers to locate what it is we want to read.

Clark Edwards

## FOOD AND AGRICULTURE

A Scientific American Book, W. H. Freeman and Co., San Francisco, 154 pages. 1976. $9 ($4.95 paperback).

Eminent biological and social scientists (mainly economists), on the disciplinary end of the disciplinary/practical problem spectrum, contributed the 12 articles in *Food and Agriculture*, originally published in the September issue of *Scientific American*. At the disciplinary end, the articles are relevant and important for agencies and persons concerned with food and agriculture. But the articles' authors treat collectively, and hence in a multidisciplinary way, only *part* of the information necessary to solve problems in these areas. Solving most such problems requires more than uncoornated knowledge from the biological and social sciences.

The infinitely numerous, complicated problems making up what is simplistically called *the* (singular) food and agriculture problem have many other facets, including political, military, medical, and demographic dimensions, which are neglected in this set of articles. Most problems and their solutions have institutional and human dimensions as well as technological dimensions. Yet these articles involve primarily the technology (including nutrition), the economic consequences of changes in technology, and, occasionally, the simple institutional changes needed to get modern inputs produced, distributed, and used. People are treated mainly as alimentary systems and maximizers (as guts and utility grabbers). Sex drives, population control, ethics, values, military power, health, political aspirations, and, even, energy are among the essential but neglected subjects.

The real income generated by food producing resources cannot be redistributed without acquiescence, altruism, or the exercise of moral, political, police, and military power. Significantly, the need for redistribution results from actions of those who do not accept equal responsibility for population control while demanding equal access to food for themselves and their progeny. The inappropriate mix of disciplines presented in this book means that the question posed in the foreword cannot be answered. That question was: "How will the world feed the three billion additional people who will join the population between now and the end of the century?" Indeed, if the problems involving food are as serious as some envision, the extra three billion may never survive or even be born.

This is not the only "food and agricultural effort" which has suffered from inappropriate disciplinary mixes. Others include the May 1975 issue of *Science* (*1*); The *World Food and Nutrition Study* by the Board of Agriculture and Renewable Resources (BARR) of the National Academy of Science (NAS) (*8*); *Agricultural Production Efficiency* also by BARR, NAS (*7*); *Crop Productivity—Research Imperatives*, sponsored by Michigan State University and the Charles F. Kettering Foundation (*2*); and *African Agricultural Research Capabilities*, NAS (*6*).[1] The current phase of the NAS World Food and Nutrition Study continues the same pattern.

[1] Italicized numbers in parentheses refer to items in References at the end of this review.

Two separate world conferences have been held—one on population in Budapest and the other on food in Rome. Inappropriate combinations of disciplines and the separation of food from population make it difficult to consider these two conferences as parts of an integrated system. This brings us to the second general difficulty with efforts of the type reviewed here. Most of them fail to take a systematic view of food production, utilization, and nutrition. This failure occurs for the farm level as well as for local, national, and international levels.

General models of food, population, and income distribution systems are not new. There is the Malthusian model and the more complete model of J. S. Mill in Book IV of his *Principles of Political Economy (5)*. The Mill model was updated in 1945 by T. W. Schultz in *Agriculture in an Unstable Economy* (9). Schultz's model has been used to analyze farm production, food, nutrition, and income situations in separate individual countries but not globally. Hence, the physical, economic, political, and military heterogeneity of the world has not been neglected though, of course, worldwide models and conclusions have not been produced.

The heterogeneity of the world must be recognized in any assessment of world food and agricultural priorities. Though modern technology has shrunk the world in terms of travel time, and many idealists speak of *one* world, the food and nutrition world is in fact highly fragmented. China is a separate world. Anglophone African countries are more closely tied to England than to their Francophone neighbors which are tied to France. The international transportation systems of Africa and South America are only rudimentary. Europe has just succeeded in creating a common market. Mexico and Central America are not integrated into the North American market. Man exists in food and nutrition ecological communities isolated from each other by transportation costs, trade regulations, and migration restrictions—all enforced with highly unequal distributions of political, military, and market power in space.

Recent global modeling efforts by the Club of Rome did not take this world heterogeneity into account though they did interrelate food production, population, and nutrition. They *missed* the stabilizing effect of international heterogeneity. That heterogeneity has led to regional, national, and subnational disasters in time and space, rather than to massive collapses of world populations. The real world displays greater stability than the homogeneous *Limits to Growth* models of the Club of Rome (*3*). Subsequent attempts of Pestel and Mesarovic to remedy this flaw by regionalizing the model have not added enough heterogeneity (*4*). Their models have not been addressed to political, military, and economic (market) power distributions and redistributions as these bear on the incidence of malnutrition, starvation, disease, and military casualities, and, hence, on changes in both population and incomes, which influence the demand for production and, finally, prices of food.

Clearly, there is need of a "systems understanding" of food production, population growth, changes in food technologies, institutional changes, and changes in human quality and numbers. This understanding must be global, with due attention to the heterogeneity of the real world. Chapter 1 in the *Scientific American* text by Wortman and Chapter 12 by Hopper were based on models. Similarly, efforts to develop a broader world understanding of food and nutrition will require models—but models much broader than Wortman's and Hopper's. Whether or not these broader models are computerized as is the Club of Rome model is of no real intellectual consequence, although computerization is of obvious practical consequence.

Building broader, more realistic models cannot be done by members of any one discipline if such models are to reflect appropriate disciplinary mixes. Food and nutrition, on a global scale, are too complex and important to be done by or left to agricultural specialists, nutritionists, economists, systems scientists or any other academic specialty. On the other hand, no specialty can be omitted, *a priori.*

Administration of priority assessments involving broad conceptual efforts is obviously difficult. This explains why most such exercises have not involved appropriate disciplinary mixes and have not dealt with total systems. Most food and agricultural assessment efforts have tended to concentrate on preselected topics and projects, mainly those of biologists, nutritionists, and economists. The concentration is on the disciplinary (or fundamental) basic interests of biologists and nutritionists, rather than on practical problems specific to time and space. The economists are mainly asked to run cost/benefit analysis and to help mobilize research money to support preselected projects. The preselected biological and nutrition projects probably reflect priorities within those disciplines fairly well, at least on the disciplinary end of the scale. However, relative priorities are not well established between one set—the biological and nutritional projects—and another set—research on policies and programs (international and local), and redistribution of power (market, political, military), which affect the supply and demand for food via starvation, malnutrition, disease, and war.

To establish these priorities requires us to start with questions about the *systems* in which real-world problems (*plural*) involving food and nutrition exist. After answering such questions, we can then proceed, via attention to broad priorities, to detailed priorities within such categories as biology, economics, demography, and political science.

Glenn L. Johnson
Professor of Agricultural Economics
Michigan State University

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## THE FARM CREDIT SYSTEM: A REVIEW

W. Gifford Hoag. *The Farm Credit System, A History of Financial Self-Help*. The Interstate Press, Danville, Ill. 1976. 292 pages. $6.95.

Agricultural economists generally, and those with interests in agricultural finance especially, will find *The Farm Credit System, A History of Financial Self-Help* an informative, interesting book. W. Gifford Hoag, who knows the System intimately, brings together considerable material that has been available only in separate publications, and he melds this with information that has not been readily available. However, he omits some contributions to the System by the Federal Government. Thus, in addition to being a review of his book, this note contains an exploration of some of the Government's contributions to the Farm Credit System.

Hoag treats the significance of the Farm Credit System to farmers and the economy, basic principles followed in its development, and the System's relationships with other organizations and groups. The book includes a chronological listing of relevant events. A more detailed table of contents or an index would have been helpful, particularly because a topic is often discussed in more than one place, and some duplication thus exists.

The author emphasizes the role of farmers as financiers, the focus of the Farm Credit System on people rather than profits, and the System as an essential link between financial markets and farmers. He points out improvements in farm loan practices initiated by the Farm Credit System, such as amortized loans, budgeted loans and the line of credit, intermediate-term loans, the future payment fund, and variable interest rates.

The author brings out the early enthusiastic accept ance of the Federal Land Bank System by farmers as indicated by the large number of National Farm Loan Associations (now Federal Land Bank Associations) which were organized, subsequent problems caused by these small associations with overlapping territories, and steps taken in reorganizing and rehabilitating the associations. Hoag outlines problems faced by the Federal Land Banks and Federal Intermediate Credit Banks in the twenties and conditions leading to creation of the Production Credit Corporations and Production Credit Associations and the Banks for Cooperatives in the depths of the Great Depression of the thirties. Subsequent changes are treated too, including the merger of the Production Credit Corporations into the Federal Intermediate Credit Banks. The question is asked, "Why so many separate organizations?" A good, although brief, answer is given, together with discussion of efforts by System banks and associations to better serve farmers.

The relationship of the Farm Credit System to various other agencies and organizations is explored, as are political pressures affecting the System and its development. The discussion on adverse political pressures is perhaps the most useful, since such information is not generally available elsewhere. We learn about the politics involved in transfer of the Farm Credit Administration to the U.S. Department of Agriculture in 1939, "political overtones" in some appointments, and other pressures during the "Department of Agriculture years." Also examined are pressure by the U.S. Treasury on the System during the credit crunch of 1966, and a small cut by the President of the United States in one Bank for Cooperatives' debenture issue during the credit crunch.

The use of names of many people involved in the history of the System adds interest. The author gives the positions that many of these people held both within and outside the System. The use of photographs is an asset: there are pictures of governors of the Farm Credit Administration, various Presidents of the United States signing farm credit acts, and district Farm Credit Bank buildings.

The chapter and section headings are excellent, but readers may wish, as this reviewer does, that more "meat" had been provided. For example, Chapter 22, "Before the Land Banks - 1620 to 1916", probably was included to portray the mounting need for credit in agriculture and the forceful pressures that developed; that is, the economic conditions justifying creation of the cooperative Land Bank System, and, a few years later, the Federal Intermediate Credit Banks. However, only about four pages of the chapter are devoted to this long period. The section, "Pressure for Credit Increases," includes only 10 lines comprising 5 sentences. Yet, history indicates the gravity of the agricultural situation which developed during the late 19th and early 20th centuries was second only to that of the Great Depression. Albert S. Goss, who played a major role in development of the land banks and of the whole Farm Credit System, particularly in the thirties, experienced firsthand the problems which confronted farmers, particularly the prevalent 3- to 5-year term real estate mortgage. When a young man, he purchased a "good" farm with a 5-year term mortgage, but subsequently was forced by "due dates" to trade 4 times. Years later he said:[1]

[1] From an unpublished address of A. S. Goss, then Master of the National Grange, Washington, D.C., before a meeting of stock-

When I was a kid I got chased by a turkey and was nearly scared to death; and I have been chased by a bull, but if you ever want to get a real case of being chased by something that's tough, it's being chased by a due date. That due date chased me around in four or five different counties between Washington and Oregon and I finally landed with a farm with a $6,000.00 mortgage and almost no equity, but the due date at least was five years off. I made up my mind that time that if ever I got out of debt I'd never get back in again, and I made up my mind that if I ever got in the business of lending money, or dealing in credit, which I considered the most hard-hearted business on earth, I hoped some kind friend would shoot me.

The book would be of considerably greater value had it been written with less bias in favor of the Farm Credit System and more objectivity. The System is large, it has stature, it is well accepted in the financial community, and it provides a large proportion of credit extended to farmers and ranchers. The System can stand on its own. Therefore, an objective analysis recognizing and considering all factors involved, including the full financial contribution of the Federal Government, would have provided a more valuable history.

In portraying the history of the Farm Credit System as one "of financial self-help," Hoag does not recognize the extent of the financial help provided by the Government. Webster's New World Dictionary defines self-help as ". . . taking care of oneself without outside help . . .". Hoag does recognize the initial capital provided by the Government without which the System would never have been created. He includes information on paid-in surplus and some other financial assistance provided the Land Banks by the Government in the thirties to help them to survive the Depression. However, a number of financial contributions by the Government are not discussed.

For example, the bid price on land bank bonds dipped to 71 in September 1932, and practically no bonds were issued from 1929 to 1934 for public sale. Those which were issued were usually sold to the Federal Reserve Banks or to the Reconstruction Finance Corporation.[2] The System made use of the revolving funds provided by the Government for such emergencies.

The Farm Credit System obtained financial benefit from a Government appropriation of $2 million in 1933, and from interest-free capital provided by the Government. Arnold reports that the $2 million was used by the Washington office for administrative expenses in connection with establishment and supervision of the Production Credit Corporations and the Production Credit Associations from 1933 to June 30, 1942.[3] The interest-free capital, together with income generated from operations, provided the funds from which the banks and associations paid their expenses. The earned net worth of the banks was, in effect, given to them by the Government.

The Farm Credit System has benefited substantially over the years from favored tax treatment. The Federal Land Banks, Federal Land Bank Associations, and Federal Intermediate Credit Banks have never been subject to taxation, except on real estate. The Production Credit Associations are subject to taxation except "for any year or part thereof" in which the Governor holds any of their stock, in which case they enjoy about the same exemptions from taxation as the Credit Banks. The Production Credit Associations benefited from similar treatment prior to 1957, when Government capital was held by the Production Credit Corporations. The provisions for the Banks for Cooperatives are similar to those for the PCA's.

Until passage of the Public Debt Act of 1941, the bonds and debentures sold by the Federal Land Banks and the Federal Intermediate Credit Banks and the derived income were exempt from all taxation. The Public Debt Act of 1941 took away the Federal income tax exemption, making the income from notes, bonds, debentures, and other obligations issued by the banks exempt from all Federal, State, and local taxation other than Federal income tax liability of the holder thereof. Banks for Cooperatives' debentures and the income derived therefrom are exempt from State, municipal, and local taxation, except surtaxes, and estate, inheritance, and gift taxes. Interest on such obligations was free from Federal income taxes until passage of the Public Debt Act of 1941 but has been subject to Federal income taxes in the hands of the holder since that time.

Other ways in which the Farm Credit System benefited from Government financial assistance include free use of office space in Government buildings and Government payments to the Civil Service Retirement Fund. The Farm Credit Administration was housed free in the U.S. Department of Agriculture in the District of Columbia until 1972, as required by law.[4] The Farm Credit Act of 1971 provided that the Farm Credit Administration should either pay rent or provide its own quarters (Sec. 5.15 and Sec. 5.17).

Full-time employees of the Farm Credit Administration have always been covered by the Civil Service Retirement System. Employees of the Farm Credit Banks were brought under Civil Service retirement coverage in 1941 and given credit for service before that year. All bank employees continued to be covered until January 1, 1960, when the Farm Credit Act of 1959 provided that only those on the rolls as of that date could continue to be covered. The Civil Service Retirement Act which became effective in July 1957 required, for the first time, that employing agencies contribute amounts to the Civil Service Retirement and Disability Fund matching the deductions withheld from the salaries of their employees. Previously, the Government provided appropriations to supplement deductions withheld

holders of the Federal Land Bank of Houston, in Houston, Texas, February 24, 1950. A copy of this talk can probably be found in the files of the Farm Credit Administration or of the System.

[2] American Institute of Banking. *Farm Credit Administration.* New York, N.Y., Nov. 1934, pp. 154-59.

[3] Arnold, C. R. *Farmers Build Their Own Production Credit System—organization and first 25 years.* Farm Credit Admin. Circ. E-45, Aug. 1958, pp. 84-85.

[4] *Laws Administered by the Farm Credit Administration as Amended to January 1, 1957.* Farm Credit Admin. Circ. 20 Rev., Jan. 1957, p. 4.

from employee salaries, necessary to finance the retirement fund.[5]

An analysis of Government assistance provided the Farm Credit System would not be complete without recognizing that the System was established to provide credit to agriculture throughout the country, which involves serving some uneconomical lending areas. Moreover, while the System serves large farms, it also serves many smaller farms where the per dollar cost of making and servicing loans is relatively high. As Hoag brings out, the System has helped improve the credit service of other lenders and, therefore, it has benefited farmers throughout the Nation. In turn, the population generally has benefited from a higher level and quality of agricultural production.

Aaron G. Nelson
Agricultural Economist
Natural Resource Economics Division

## TECHNOLOGY AND AGRICULTURAL DEVELOPMENT: A REVIEW ESSAY*

Since World War II, the earth's nations have experienced unprecedented economic advance, increasing interaction and interdependency, and population growth. Despite the positive impacts of these postwar changes, some 40 percent of the 2½ billion people living in lower income countries remain in abject poverty, obtaining incomes of less than $150 annually. Income and wealth gaps within poorer nations, and between developed and developing societies, seem to be increasing rather than decreasing despite both indigenous efforts to promote economic development and an historically unique era of magnanimity by developed nations. If the intensity of development efforts is beginning to wane, what hopes remain for the one billion persons left behind?

Explanations for the failure of postwar efforts to assure development fall into five broad classes. One set of arguments holds that the development effort is insufficient, that developed and developing nations are not trying hard enough, that the infusion of more resources would push the various sectors and nations over their current limiting thresholds and permit steady advances. A second set of critics argues that development efforts are misguided. It is not so much the level of effort but rather the *type* of development effort which is crucial, so the failure to aid in the right way (rather than the failure to aid enough) is held culpable for the "absence" of development. A third set of critics espouse a "villain theory"; development can never proceed until groups or institutions benefiting from current arrangements are extirpated. A fourth approach is to question our knowledge of the development process, to argue that without a cogent understanding of it, indigenous and foreign efforts are as likely to produce unfavorable as favorable results. The fifth approach to the development process adopts a different perspective; limited development reflects the intractable nature of the problem more than reliance on misguided theories or efforts. This school views development as a complex process requiring time; it counsels patience and avoids overexpectations rather than advocating new directions in development efforts. Each of the approaches (except the last) prescribes a policy *change* to expedite or alter the mode of socioeconomic development.

This essay reviews several recent criticisms of past and ongoing development efforts. First, a recent contribution to the "villain" school of criticism and an earlier example from the "misguided" school are discussed. Next, the propositions of those arguing for labor-intensive development efforts which utilize appropriate technology are examined. The essay concludes with a brief survey of persisting development problems and an assessment of the likely impacts of the criticisms reviewed.

### Villains and Misguided Development Efforts

The school of thought that identifies villains who block progressive changes and expose well-intended but fallacious strategies enjoys a long tradition in development criticism. E. Vallianatos' *Fear in the Countryside* adopts both perspectives to demonstrate the "failure" of current development efforts and to illustrate the changes necessary to assure progress (*13*).[1] The key to economic development is, in Vallianatos' view, a labor-intensive, locally adapted agriculture. Economic theories of development are summarized in a brief reference to Rostow's "stages of growth" and then denounced for their "criminal neglect of agriculture." Development efforts have been misguided because they stress the formation of capital-intensive industrial projects and will not change until the bond linking the multinational corporations of developed nations and the elites in developing nations is broken. "The thesis of this book . . . advances the proposition that the transfer of agricultural technologies to the underdeveloped countries has rarely been successful because of forbidden (sic) constraints" (*13*, p. 13). These constraints include biological specificities which limit direct technological transfers and institutional arrangements which ensure that the agricultural technology provided will not benefit the mass of peasant farmers. Rather than adapting technology to the needs of peasant farmers, profit-seeking entrepreneurs will cater to the needs of agricultural elites who already possess the land, credit, and education necessary to use existent technology without adaptation. The resulting development process accentuates intrasocietal income and wealth differences, allowing the developing societies to fall farther behind the developed, since the energies of the peasant masses remain unused or misguided.

[5] Information on the Civil Service Retirement Act and the Civil Service Retirement and Disability Fund was provided by the Civil Service Commission by letter dated March 15, 1977. Other information in the paragraph was provided by the Farm Credit Administration.

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[1] Italicized numbers in parentheses refer to items in References at the end of this essay.

The solution is to redirect the development process so that it is structured around the needs of the peasant: "The peasant farmer is the backbone and victim of both economy and poverty in the underdeveloped countries" (*13*, p. 14). Only when new technologies and institutions favoring the peasant farmer are introduced can the productive potential of peasants and rural workers be unleashed finally to solve the problem of poverty in the developing nations. Emphasis centers on the interdependency between man and technology, not man and man: "human survival will depend largely on man's ability to shape his technology to the environment" (*13*, p. 8).

Vallianatos' book is "a manifesto—a book of passionate advocacy" (*13*, p. xv); assertions abound. While it may be true that "the effort of the West to make the big landowner the main food provider of the underdeveloped countries has clearly failed," little evidence is adduced in support of this contention, since "some of my findings are not rigorously supported by extensive data" (*13*, p. 17). Although Vallianatos cautions that "the purpose of this book is to probe, not to prove" (*13*, p. 19), many readers, especially development economists, will not agree with the premises which permit conclusions to be drawn. For example, not everyone would agree that "agricultural research and institutions in the poor countries are basically irrelevant to local needs" (*13*, p. 146), precluding agreement on the need for "a veritable renaissance in appropriate agrarian technologies" (*13*, p. 161) as a panacea to the development problem.

Vallianatos' book consists of three introductory chapters, three chapters illustrating the failures of past technological transfers in Colombia, and four chapters which argue for a new type of technology and an alternative means of diffusing technology in developing nations.

Although development economists will fault Vallianatos' methods, assertions, and conclusions, the book is part of a burgeoning literature on intermediate, alternative, or appropriate technology. With the publication in 1973 of E. F. Schumacher's *Small is Beautiful: Economics as if People Mattered* (*11*), the appropriate-technology movement discovered an intellectual font for the idea that technological diversity is superior to uniformity. Rather than encouraging the production and distribution of capital and energy-intensive machinery, the appropriate-technology school contends that development efforts are misguided due to an insensitivity to differences between geographic areas. Personal and environmental changes (often deleterious) accompany the acceptance of a uniform new technology. The solution posited is to adapt technology to its local milieu, to stress labor- rather than capital-intensive technologies, and to "restore dignity to manual labor."

The interactions of technology's diffusion and socioeconomic development concern the processes by which choices are made. Given a range of technological alternatives, why do developing nations choose a particular set of inputs? Economic theory holds that choices are contingent on tastes and relative prices. Despite tastes for the new and modern, a "correct" (market-determined) set of relative factor prices ensures that the technological choices made are economically, rather than merely technically, efficient. A long literature on agricultural development finds that, for the given set of relative prices, peasant choices are economically efficient (*10*, *2*).

The appropriate-technologist school goes beyond choice decisions *given* relative prices by averring that the prevailing set of factor prices is distorted. For Vallianatos, relative prices favor capital-intensive development because multinational corporations and local elites combine to prescribe a situation in which rational choice dictates a mutually advantageous outcome; for example, machinery sales for the multinationals and pressures for land consolidation to use the machinery efficiently. Schumacher faults the relative price set for a different reason. Rather than identifying a cognizable set of villains, he argues that misguided choices result from bad values, that price-dictated choices neglect "meta-economic" values. Although meta-economic values are not explicitly defined, it is clear that their adoption would result in an alternative choice set.

Choice decisions influenced by distorted relative prices are not a discovery of persons supporting appropriate technology.[2] Development economists have long recognized the capital-using bias of policies of developing country governments which provide artificially low interest rates, price subsidies, tax credit for capital investments, and overvalued exchange rates or differential tariff structures. But developed nations have promoted capital intensity by tying aid to the purchase of certain (domestically produced) products, by ensuring that technical aid is given by those familiar with capital-intensive techniques, and by assisting salesmen who seek to distribute a technology developed for technologically advanced nations. Multinationals contribute to recognized capital-distorting practices by relying on familiar technology which can be used without adaptation. Thus, it has long been recognized that there are factors which distort relative prices and therefore choices; appropriate technologists have merely called attention to new distorting considerations.

The Schumacher school of appropriate technology identifies three sets of issues. On moral and ethical grounds, less happiness is derived from consumption of more high-energy material goods; maximizing consumption is inherently unsatisfying. A second set of arguments involves the restructuring of society to conserve nonrenewable resources, to discourage the drive for scale (bigness), to use more labor-intensive production processes, and to make work more satisfying. These arguments concern the nature of the power and decisionmaking structures which can reverse current propensities. A final set of issues is philosophic; should economic growth be the goal of a society? What rate of growth? Who should determine optimal "smallness?" The theme underlying Schumacher's arguments is a Waldenesque wish for rustic rural life, modernized by the distinction between renewable and nonrenewable resources.

The appropriate-technology school has flourished.

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[2] Some critics contend that technological choices in agriculture are wrong from yet other perspectives. Perelman, for example, criticizes American agriculture for using more energy inputs per food calorie produced than Chinese agriculture, making the set of caloric input-output ratios a basis for comparison (*8*).

The U.S. Agency for International Development has established an intermediate technology program; the United Nations has initiated multiple research and diffusion programs, including several wind, solar, and bio-gas energy projects under its environmental program; and the Organization for Economic Cooperation and Development (OECD) has sponsored a series of seminars and discussions on the subject (*3*). The London-based Intermediate Technology Development Group stresses the need for adapting technology in local developing areas while the American National Center for Appropriate Technology emphasizes the need for "self-reliant and quality-of-life improving" technologies in the United States. Given its recent origins, the diffusion of the appropriate-technology ideas has been very rapid, providing evidence of a strong undercurrent of popular desire for a return to local autarky, even in the United States (*14*).

If intermediate technologies are to be encouraged, who should bear the burden for their development and diffusion? Bhagwati assigns the task to the developing countries: "It is really up to the labor-abundant, developing countries to direct their scientific research to turning out superior, labor-intensive techniques" (*1*, p. 193). Others argue that the donor nations should direct developing nation strategies by specifying how foreign aid is to be used. Sweden, for example, demands that its aid monies have employment-increasing impacts, and the European Economic Community has embraced labor-intensive project proposals even if the total cost of the project escalates (*7*). If donor nations continue tying their aid to specific projects, fewer funds are then available for the relatively risky research on intermediate technology, a risk compounded by the limited spatial and duration characteristics of the market for such innovations. Intermediate technology, as with many other development ideas, is as much a strategy developed and advocated from the affluence of donor nations as an outgrowth of indigenous efforts.

## Technology and Persisting Development Problems

Development is a relative concept; across time and space, its "stage" or "level" is held to be assessable against objective benchmarks. The presence of societies at different levels of development has two important implications: (1) the existence of both advanced and less advanced societies makes the strategy of imitation omnipresent and (2) the search for objective benchmarks to compare development across time and space leads to the use of quantifiable development indicators.

The fact that role models exist, that the "end" is visible and mensurable, permits the imitation strategy to adjust means more than ends and reduce the time necessary to reach a given development end. The dominant objective benchmark has become the level and growth in GNP, permitting the *definition* of underdevelopment to be translated into a monetary criterion. As with many such complex processes, definitions of the problem are important, since the definition often contains within it the seeds of a solution; for example, develop by increasing the level and growth of GNP.

Making the level and growth of GNP the *denouement* of the development process obscures related but intermediate problems. Development economists often identify three pressing concerns: (1) unemployment and underemployment, especially in urban areas as a result of rural-urban migration;[3] (2) failure to move toward income and wealth equality; and (3) population growth (*9*). A development strategy centered on aggregate output growth implicitly assumes that these intermediate problems will be solved as a byproduct of growth.[4] Despite a concerted 30-year effort, the intermediate development problems remain, partly because their presence has been obscured by the definitions used.

Rural-based, small-scale, labor-intensive development strategies have refocused attention on intermediate problems rather than final solutions. Intermediate technology is seen as one way of assuring more rural employment and of limiting the income inequalities introduced by capital-intensive technologies available only to the few. The recent criticisms have a common thread—development efforts must concentrate on the small farmer and the agricultural sector, not the more visible capital-intensive industrial sector. The population problem is not explicitly addressed; as with other theorists, the implicit assumption is that increased economic security will naturally reduce fertility. Even measured against its own criteria, the appropriate-technology strategy must be seen as incomplete.

Deflection from GNP targets and concentration on an employment-increasing agricultural strategy has both benefits and risks. To improve life for the masses, the fraction of total income in the hands of the rural and urban poor must be increased, either by measures which increase employment or via income transfers. The advocacy of rural-oriented, employment-increasing policies is not confined to those espousing appropriate technologies (*4*, *5*); but the technologists often neglect the economic and political risks which accompany such strategies. If the income elasticity of demand for food is high, then much of the additional income transferred to the poor will be spent on food.[5] If the extra income available to the poor is diverted from those with higher savings propensities, then the rate of investment and capital formation may slow, especially if additional food imports are necessary to meet the additional food demands.

An even greater risk for the domestic development planner is that strategies can be irreversible; once set in motion, a strategy aimed at ameliorating conditions for

[3] The urban unemployment resulting from urban industrialization and rural-urban migration provides yet another illustration of the complexity of the development process. Too often, interdependencies and linkages are not well understood, permitting "unanticipated" problems (urban unemployment) to follow from desirable strategies (increased domestic production). Todaro has documented the extent to which such linkages have worked in Africa (*12*).

[4] The relationship between population and per capita income permits the limiting of population growth to equal an increase in per capita income *if*, for example, additions to population have zero (or even negative) marginal productivities.

[5] Mellor has estimated that the marginal propensity of consumption for food is about 0.85 for the lowest income quintile in India and 0.02 for those in the top decile (*6*), indicating that income and wealth transfers *will* tend to increase food consumption and lower savings.

the masses can be reversed only at great cost. While the long term goal may remain equality and affluence, planners may argue about the *timing* of new policies designed to achieve that end. Although more choice in development strategies may be available than is often supposed, the choice process must still involve a myriad of benefits, costs, and risks.

The technology-development debate is not settled. What the appropriate-technologist school has done is to question the implications of long-dominant economic theories. The theory of international development and trade argues that a given set of world and domestic prices will permit each nation to maximize production by selecting those outputs in which it has a comparative advantage. But the theory assumes "market-determined" prices; if markets are manipulated, then a country's "comparative advantage" may be artificially maintained by particular foreign or domestic actions. Such an artificial comparative advantage may promote inequality within societies; for example, the oft-asserted dictum is that peasants produce luxury foods (coffee, sugar, and the like) for foreign consumption under relatively capital-intensive conditions, ensuring excess labor and low wages, but these peasants must purchase foodstuffs (such as rice) which are imported from countries where very different capital-labor ratios prevail. Even if such arrangements make the peasant better off by some absolute consumption standard, the inequality engendered may leave him worse off in a utility framework.

Technology affects development via its influence on product design, production facilities and processes, organization and marketing techniques, and its broader impacts on skill and educational levels and priorities, profit and power potentials, and international interdependencies. Technology is either acquired, adapted from exogenous sources, or indigenously developed. Since the developed societies do virtually all research and development work, it is natural that the resulting innovations are generally directed toward meeting such societies' needs. But the *creation* of technology differs from its *transfer*; the issues raised by those who favor appropriate technologies are much more an indictment of current modes of transfer rather than a condemnation of technology's creation. What is required is more sensitivity to local needs rather than a reorientation of science.

Development literature often tends to adopt a messianic aura; given a desperate problem, it identifies (a set of) culpable factors responsible for persisting poverty and comes up with means for their dissolution. Development consultants often appear as sacerdotal savants waging theological wars over degrees and levels of intervention which can eliminate poverty and misery. But poverty and misery have been universal in both time and space. Efforts to eradicate poverty (or at least mitigate its consequences) antedate modern technology and economic theory. The appropriate-technologist school injects a needed evolutionary perspective into the debate; while technology often "overpromises" because of its ability to perform tasks at superhuman speeds, appropriate technology stresses the link between human understanding and human technology. Which mode of development is "better" is not a realistic question, but the introduction of another view can only be welcomed as a counterweight to dominant theories which have enjoyed limited success.

Philip Martin
Assistant Professor of Agricultural Economics
University of California-Davis

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## MICROPOLITAN DEVELOPMENT

Luther Tweeten and George L. Brinkman, Iowa State University Press, Ames. 456 + ix pages. 1976. $20.

Luther Tweeten and George Brinkman are ambitious scholars. They have tried to produce a book that "can be used as a classroom text, a book of readings, a reference, or a guide to rural development practitioners and decisionmakers." Such a goal is admirable, but it must be regarded as terribly naive when the subject is the development of nonmetropolitan areas in the United States. Hundreds of scholars have bent their attentions to this theme. Only a few have been able to comprehend the

problem in more than one or two dimensions.

*Micropolitan Development*, though a book with many dimensions, does not define a comprehensive set of ideas or theories related to its primary subject. Instead, it represents a collation of results, reviews, and opinions generated by many authors and scholars who have worked at micropolitan development in recent years. The book is a reference book and nothing more. But it is a very good reference book because it comments on scores of contemporary researches, theories, and ideas. It will find a useful place on the shelf of any teacher, researcher, practitioner, or serious student of micropolitan, rural, or community development.

The book is organized in a familiar way. The problem is defined and placed in context, the goals of problem solving and public policy are presented, then the work of the theoreticians is described. When theories are well in hand, the authors turn to specific classes of problems—human resources, community services, and industrialization. The final chapters are devoted to institutional problems, organizing for development, and planning. On the surface the book seems to cover the right subjects in the right order. Though honest in what they achieve, the authors mislead in promising readers more than they deliver.

Every land grant university has at least one instructor who needs a textbook to use in the proliferation of courses on rural development, rural community development, human resource development, or even micropolitan development. Tweeten and Brinkman have named the subject that a text should cover, but they have not written a textbook.

A text must start with a single thread and hold to that thread throughout. Authors cannot claim to be presenting a subject and then discuss only what impinges on the subject or results from the subject's problems. There is neither theory nor a well-defined practice of micropolitan development in *Micropolitan Development*; thus, the book becomes a compendium, not a text.

The chapter on theory alone is worth the price of the book. Tweeten and Brinkman, by adding a special twist, come to grips with the heart of the problem. Many authors of specialized books in economics, particularly in the subfields of agricultural economics, devote an early chapter to theory then turn to other matters without ever returning to use the theory. In *Micropolitan Development*, the chapter is correctly titled "*Theories* of Micropolitan Economic Development" (emphasis added). It contains a list of theories available for use in analyzing the special problems that may arise in certain micropolitan areas. While one might question the choices (Why are the Harrod-Domar models included? Why are the Innis theories omitted?), the level of treatment is acceptable and the inclusion of theories of public involvement, commendable.

Given the authors' previous involvement in research, it is not surprising that they devote much space to human resources. Even though this topic should be of special interest, devoting one-fourth of the book to this subject seems too much. True, the labor force (Chapter 4), education (Chapter 5), and poverty (Chapter 6) are important characteristics of micropolitan areas, but the treatment need not be so exhaustive and repetitive. One wishes there were more on causes, effects, and interrelationships; less on documenting the obvious. While it is useful, for example, to know that poverty exists, it is also useful to know the origins of the poverty and the relative success of alternative programs designed to alleviate poverty. It is characteristic of the book that problems are overdocumented; analyses, solutions, and public policies, underdocumented.

The chapters on organizing and planning are at best disillusioning and at worst possibly dangerous. Despite the authors' continuous admonitions, some practitioners—especially those who embrace the process approach to development—will use these chapters in a cookbook fashion. They will follow each step in a rigid sequence that identifies problems, generates interest, specifies goals, develops plans, then calls for sitting back to watch while improvement marches into the area. This is as much the readers' fault as the authors', but it underscores the naivete of all who are involved in the process of development. Development can *sometimes* be planned, but caprice and whimsy remain important elements. The authors could have done a service by including a chapter on coping with failure. Perhaps such an apology or warning is beyond the pale of economics, but someone who is learned and intensely involved with rural development should be awakening the diverse clienteles to the fact that the odds are stacked in favor of failure rather than success and that even the best of plans and efforts may go unrewarded. This conditioning theme cannot be found in Tweeten and Brinkman's book.

In sum, Tweeten and Brinkman have provided a useful piece of work. It is not as general as they would have readers believe, but it will be helpful to many people. In its role as a compendium, it has few competitors. It replaces A. F. Wileden's *Community Development* (The Bedminster Press, Totowa, N.J., 1970) in providing immediate access to and commentary on the results of hundreds of researches, papers, and articles.

The book does not, however, come close to an analysis of the micropolitan development problem. For this, we will continue to depend on Vidich and Bensman's, *Small Town in Mass Society*, revised edition (Princeton University Press, Princeton, N.J., 1968) and its indepth look at the problems of "Springdale." For showing the relationship between the national economy and the regional economies, Niles M. Hansen's *Rural Poverty and the Urban Crisis* (Indiana University Press, Bloomington, 1970) remains the superior book. However, Tweeten and Brinkman set out to study the studies of others. They did this well and for this effort they are to be thanked. They should, though, be encouraged to rethink the book they wanted this book to be. They should unleash their considerable analytic prowess to find the threads that can be woven into a *text* relating to the development of nonmetropolitan areas.

Paul W. Barkley
Professor of Agricultural Economics
Department of Agricultural Economics
Washington State University

## THE NEW ECONOMICS OF GROWTH: A STRATEGY FOR INDIA AND THE DEVELOPING WORLD

John W. Mellor, Cornell University Press, Ithaca, New York. 335 + xv pages. 1976.

John W. Mellor's new strategy for alleviating poverty in the developing countries aims at employment; the major stimulus to growth comes, from cost-reducing agricultural technologies. The poor, Mellor argues in *The New Economics of Growth*, can only participate in the development process if the demand for their labor increases. Poverty, in other words, is a function of the structure of economic growth; it cannot be readily eliminated by increasing public welfare expenditures or redistributing income.

Substantially raising the incomes of the poor, however, will increase their effective demand for food. Unless food can and will be massively redistributed, putting people to work will require rates of increases in food production in most countries far in excess of those achieved under previous growth strategies. Increased food production, Mellor concludes, must be a prime component of any program designed to increase the welfare of the poor.

The necessary increases in food output, Mellor argues, must be obtained through technological innovations. Unless cost-reducing agricultural technologies can be developed, agricultural production costs will rise and the productivity of labor and other nonland resources will decline as output rises. More capital and other resources will have to be transferred to agriculture to achieve a given growth in production, slowing down the rate of growth in other sectors. Higher production costs will also lead to higher food prices, discouraging more labor-intensive development throughout the economy. As a result, the additions to national income from agriculture will, in the long run, be offset by the losses in potential income from other sectors of the economy.

Rising food costs could be prevented by resorting to food imports or food rationing. Developing cost-reducing agricultural technologies is the superior alternative, Mellor argues, but not a costless one. Technological advances in agriculture require expenditures on research. Massive investments will also be required in rural physical infrastructure (such as irrigation systems and rural transport and communication systems) as well as in the institutional infrastructure for servicing agriculture (for example, research, education, credit, input and product marketing systems).

When the necessary increases in food production come through the application of cost-reducing technologies, the resulting increases in rural incomes will set in motion a sequence of multiplier effects, according to Mellor, which will stimulate expanded production and employment in other sectors of the economy. The unique twist in Mellor's argument stems from his recognition that this multiplier process can continue to work even though the initial benefits of these technologies may be captured by the more prosperous rural people. For example, cost-reducing agricultural technologies will enable the wealthier landowning classes to produce and market more food. The extra cash they receive will be spent primarily on nonagricultural commodities. Since the consumer goods which they purchase are relatively labor intensive, more people will be employed as a result of their increased incomes and expenditures. The newly employed, lower income, laboring classes, who spend most of their incomes on food, will provide the demand for the additional food produced. The circle must be completed for this strategy to work. If the number of lower income people employed does not increase sufficiently, for example, demand for the increased agricultural output will be inadequate and agricultural prices may decline sufficiently to discourage continued growth in agricultural production.

Mellor tests this strategy in India—the stronghold of the capital-intensive approach to development. He looks at the sources of current development in India, diagnoses the successes and failures of the capital-intensive approach, and projects what might have happened to employment under alternative assumptions about rates of growth in food grain production, technologies, and population.

While emphasizing the agricultural sector, Mellor also stresses the interrelationships among agriculture, industry, trade, aid, social welfare programs, and the planning process itself. The relative importance of consumer goods and other small-scale decentralized industries will have to increase under Mellor's employment-oriented strategy as rising rural incomes bolster demand for their output. Additional supplies of capital will be needed both to develop agriculture and to expand the consumer goods industries, but now each unit of capital invested will have a greater impact on employment because such industries are relatively more labor intensive. A combination of factors will also encourage the decentralization of production to rural areas. Rural demand will be higher. Higher rural incomes and increased production will also encourage investment in rural transportation, communication, and electrification—all important to the development of rural, small-scale industries. Higher rural incomes should also provide additional sources of capital for investment in local, small-scale industries.

Larger quantities of intermediate products produced with highly capital-intensive processes will have to be imported to support the development of agriculture and the consumer goods industries—fertilizers and pesticides for agriculture and steel, petrochemicals and synthetic fibers for industry. Domestic manufacture of these products would divert capital from agriculture and consumer goods industries which must provide the bulk of the employment. "Fortunately," as Mellor points out, this same strategy will help expedite exports of labor-intensive products by raising the supply of wage goods (food and consumer goods) and thus of relatively low cost labor.

Four types of changes must occur, Mellor concludes, for India to shift to an employment-oriented strategy. Priority must be given to agricultural production by investing in new technology. Capital requirements per employee in the industrial sector must be reduced and new sources of capital tapped through decentralization of production. Export and import growth rates must increase to expedite the decrease in capital intensity. And planning and administrative procedures and institutions must be decentralized and the emphasis switched from regulation to facilitation.

Mellor, more than most economists, not only recognizes the importance of administrative and political factors but he also can tell us what his economic strategy will require in the way of changes in institutional structures and administrative styles. Central determination of resource allocation and a system of restrictive licenses and controls designed to prevent the distribution of resources perceived as undesirable was consistent with India's capital-intensive strategy. If an employment-oriented strategy is adopted, India's administrative structure will have to become much more decentralized, Mellor concludes, and more attention given to facilitating rather than controlling development. Agricultural development, because of great variations in production conditions, must be a considerably decentralized process. Consumer goods industries and other small-scale enterprises, such as agriculture, are more likely to prosper with more decentralized decisionmaking and public provision of credit, transport, marketing, and technical and other services.

Whether this strategy is relevant to the rest of the developing world, as Mellor's title claims, is open to serious question. Everything depends on who gets the extra income from the new technologies and what they do with it once they get it. If a small group of very wealthy landowners are the initial beneficiaries, and they spend their increments in income on imports and/or capital-intensive goods, the multiplier effects will be initially different than if other groups benefited. Growth measured in GNP may be stimulated but not employment or equity. If employment and equity are also objectives, the old but politically difficult solutions still seem to apply—redistribution of assets or income or both.

Mellor argues that, in the peasant agricultures which predominate in Asia and Africa, the expenditure patterns of the initial beneficiaries of agricultural technologies will encourage the expansion of labor-intensive consumer goods industries. Latin American countries are conspicuously absent from this list. Mellor has evidence from India to back up his contention. A recent analysis of rural consumption patterns in Sierra Leone found that rural consumers did purchase primarily labor-intensive goods.[1] This analysis also provides support for the hypothesis that low-income groups purchase more labor-intensive products than do high-income groups. Until more evidence is gathered, however, Mellor's hypotheses are just that—hypotheses.

Roberta van Haeften
Agricultural Economist
Foreign Development Division

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## INTERCROPPING IN SEMI-ARID AREAS

J. H. Monyo, A.D.R. Ker, and Marilyn Campbell, eds., International Development Research Centre, Ottawa, Canada. 72 pp. 1976.

Intercropping is the mixing or interplanting of a number of different crops on the same piece of land, at the same time. It is almost universally practiced by small farmers in most tropical countries, but, in spite of this, agricultural research workers in the tropics have generally tended to neglect the complicated intercropping systems and to concentrate on research on one crop at a time, as is done in temperate regions. Recommendations based on the results of this research were then made to the small farmers so that they might improve their crop yields. The farmers almost invariably rejected these attempts to impose alien single-crop systems on them, and continued their own traditional intercropping practices.

A symposium on intercropping to share the results of agricultural research to correct for this lack of relevant knowledge was held at Morogoro, Tanzania, in May 1976. The 30 papers presented are summarized in this interdisciplinary report. They cover: soil management and fertility; crop combinations; plant breeding and crop physiology; pests and diseases; experimental methods; and economic and social aspects of intercropping.

The traditional agriculture inherited by the peasant farmer was designed to raise sufficient food for himself and his family in a situation where very little else was required. There were no taxes, no school fees, no goods for purchase, low population levels, and little pressure on the land.

Death control, costs of a country-wide government organization, education, and material needs of Western civilization have changed all this. The farmer now has to produce a lot more from continued use of the same piece of land.

As researchers, we have to ask ourselves: Is the intercropping technology that we have developed thus far sufficiently superior to that already used by the farmer? We need to look at what the farmer is doing, and why he is doing it.

The farmer has tried many possibilities during the last thousand years, but we may be able to bring in new crops, new crop varieties, new ideas of cropping patterns from other countries. The main possibilities for improvements are new varieties, oxen power and improved implements, fertilizers, and weed control.

Improved varieties often involve a redistribution of total dry matter production so that much more of it is grain. This gives the farmer an immediate yield increase without additional inputs. On this can be added simple agronomy practices, provided the new varieties are responsive, which they must be. Only then can we think in terms of farming systems.

However, population pressure is increasing and time is running out. Increased production per unit is essential, and governments will be faced with the hard decision on whether these changes can be induced by persuasion or whether state control is necessary to make the farmer adopt new ways.

[Extracted from the report.]

## VILLAGE WATER SUPPLY: ECONOMICS AND POLICY IN THE DEVELOPING WORLD

Robert J. Saunders and Jeremy J. Warford. Published for the World Bank by the Johns Hopkins University Press, Baltimore and London, 279 pages. 1976. $15 ($6 paperback).

Water-associated diseases are related to the availability of water and sanitary facilities. Yet most people in developing countries do not have "reasonable access" to a "safe" water supply or adequate means of waste disposal, according to the World Health Organization. Thus, investment in rural water provides both economic and human benefits. Robert J. Saunders and Jeremy J. Warford present several: An increase in overall economic activity if funds come from outside the country; an improved infrastructure which will attract more investment; availability of water for fish farming, irrigation, and livestock; an increase in property values; reduced human mortality and morbidity, more time for productive work, especially among women and children who draw the water; fewer medical expenses; improved tourism; and, "if it is assumed, first, that carrying water requires more calories than the substitute activity," there will be a decrease in the cost of personal consumption. The last observation may seem trivial, but it illustrates the authors' thoroughness.

Saunders and Warford present a regression analysis that attests to economies of scale in water supply and waste disposal. However, per capita cost, they say, is not enough of a criterion for establishing priorities. One also needs to consider growth-point strategies, "worst-first" strategies (which could easily give the nod to urban areas), community enthusiasm, and quality of the existing water supply. Sometimes the decision that sets a priority is political, the authors point out; other times it is based on mathematical formulae. The criteria suggested above are at best only screening devices, since it is extremely difficult to measure benefits. Willingness of consumers to pay, at least in excess of a basic minimum, represents a more rigorous method of setting priorities, according to the authors.

Underemployment and overvalued currencies tend to characterize rural areas of developing countries, and development funds are available at interest rates below opportunity costs. Therefore, the authors believe, a major job of the economist is to value the factors of production so that a clear choice can be made between labor and capital among alternative projects. For example, the quantity of water consumed can be more important than the quality in the incidence and prevalence of some diseases; money spent on "absolutely safe" water for a few people might be better spent on "reasonably safe" water for more people. Another example which the economist's work can help to solve is whether to install household connections, which cost more but increase per capita consumption, or to have village standposts and fountains.

Poor operation and maintenance of existing systems is widely believed to be the single most important obstacle to rapid improvement in village water supply. Saunders and Warford visited two countries where the "systems were actually failing at a more rapid rate than they were being constructed." A survey in another country "showed that 69 of 79 rural water supply systems had some difficulties in operating their plants." Many countries lack facilities to train bill collectors, bookkeepers, pump operators, and community promoters. Engineers do not want to live in backward rural areas. Low wages can mean that many people must take a second job or they may resort to considerable pilferage. Finally, there are frequent subsidy cutbacks by the central governments in these countries.

The authors conclude with a discussion of methods for regulating water consumption, such as marginal cost pricing, metering, social pressures, and physical restrictions in valve design and reservoirs. The book is mainly for policy planners and sanitary engineers but persons in related fields, such as health care and foreign service, should also find it useful. The book contains an excellent current bibliography of 23 pages.

Howard Christie
Economist
National Economic Analysis Division

## THE JOURNAL'S NEW LOOK: AN ASSESSMENT

*Agricultural Economics Research* (AER) has been under "new management" since January 1976. Time enough has elapsed to begin to form an impression of the "new look" in what has heretofore been one of the profession's more obscure publications.

Substantial progress has been made on several fronts. First, distribution. After more than 14 years of trying, I seem to have succeeded in getting my name added to a distribution list. Moreover, it is less difficult to find copies of the journal within ERS. And the outside world is being better notified of the existence of AER and provided a workable subscription system.

What of the publication itself? The cover has been brightened and the Research Review section is a lively, if unusual, mixture of well-edited book reviews and brief notes. The body of the journal, the articles, are also well edited, and the graphics quality of the figures and tables has improved appreciably. At only $3.85 a year, it is clearly a "best buy."

Alas, however, the articles continue to be rather heavily quantitative in orientation and/or presentation. In the April 1976 issue, one of the two editors, Clark Edwards, acknowledged that the three articles "depend heavily on mathematics, statistics, and computers" (p. 75). And in the January 1977 issue it was stated that "the three articles in the issue explore ways to become more rigorous" (p. 19); rigor was associated with mathematics.

This orientation may meet the recommendation of the AER review committee that "emphasis continue to be on technical articles and that articles reflect major research in the Department" (January 1976, p. 34). Yet one can't help but hark back to editor Edwards' question in the April 1976 issue (paraphrasing Sir William Hamilton) as to "whether these articles are evidence of dullness in ERS elevated to a talent, talent degraded into

an incapacity, or neither of the above" (p. 75). The recent selection of AER articles suggests that this question may not have been entirely rhetorical.

To harbor such thoughts may, of course, be considered heresy by some, and is at least unfashionable. Editor Edwards has observed (darkly?) that there are those "with an antimathematics or antiquantitative bias" (January 1977, p. 19). Lest I be readily dismissed as such a crank, let me hasten to suggest that there is a middle ground, that composed of agricultural economists who recognize the importance of mathematics but who also think that English can be a vehicle for rigorous thought and a useful medium for communication.

Yet the artful use of English in agricultural economics has declined to the point where there are only a few notable practitioners (T. W. Schultz is one). A recent book by Harold Breimyer moved R. J. Kohls to comment in AER that "It is refreshing to receive the communication of stimulating ideas from a craftsman who can creatively use the language in other ways than as footnotes to tables, graphs, and computer printouts!" (January 1977, p. 25).

All of this could lead one into a tedious discussion of the role of quantitative techniques in economic analysis and communication. But this subject was thoroughly discussed at annual meetings of the American Farm Economics Association over a decade ago and comments appeared in the *Journal of Farm Economics*.[1] I do not propose to hash it over again, but I can't resist citing the following statement which suggests how little one side of this issue has changed over the past 300 years:

> . . . an effective, though unrecognized limitation of the field of seventeenth century science was due to this preoccupation with mathematics. Those parts of experience that could not then be reduced to mathematics tended to be left out, and even those parts which were not suitable for mathematics tended to be treated mathematically, with somewhat ridiculous results.[2]

Even if one thinks that the article balance or article content in the AER might shift a bit more to the literary side, there are several constraints. One is the total space limitation of 160 pages per year. Over the past 5 issues, the space devoted to articles has averaged only a modest 26.6 pages per issue; in January 1977 it was only 18. Mathematical/quantitative articles tend to be relatively shorter than more literary works. A second problem is that editors are largely prisoners of submitted material. If they receive only mathematical/quantitative articles, they don't have much choice in what they print.

The latter point raises a question concerning the motivations and desires of the research author. One rather uncharitable editor has said:

> Do researchers want to write clear literate papers, instantly crystal clear to all readers? They do not. They want to get a paper published that will impress their peers. And if nobody else understands, so much the better.[3]

Joseph Willett of ERS contends that "economists *can* say things to ordinary people, but tend to use technical jargon to show the profession they're with it."[4] One would hope that ERS economists would have higher motivations.

Where does this leave us? The answer depends in part on the purpose of AER. If it is principally intended to communicate with other economists, particularly those with a quantitative bent, then perhaps the AER article balance is satisfactory as is. But if a wider audience is desired, even among economists, one might suggest that contributors and editors give further attention to reducing dependence on mathematical symbolism in articles, and that prospective contributors be notified that more literary contributions, and in fact articles largely devoid of equations, would not be scorned. Alternatively, perhaps another journal reporting ERS research but aimed at a more general audience might be established.[5]

Such steps could help improve the communication of the results of research conducted by the Economic Research Service without seriously reducing rigor or inducing rigor mortis.

Dana G. Dalrymple
Foreign Development Division

[1] December 1963, pp. 1386-1407; December 1965, pp. 1479-1503. I would particularly recommend the papers by Don Paarlberg on "Methodology for What?" (December 1963, pp. 1386-1392) and by R. J. Hildreth on "Have We Gone Too Far?" (December 1965, pp. 1497-1503). Several other papers are also relevant: Don K. Price, *Government and Science*, Oxford Univ. Press, 1962, Chap. VI ("The Structure of Policy"), pp. 160-189; Bernard R. Hoffnar, "What Did Our Readers Mean?" (contains a delightful quote from Pigou), *J. Farm Econ.* Feb. 1965, pp. 150-151; and Axel Leijonhufvud, "Life Among the Econ," *West. Econ. J.*, Sept. 1973, pp. 327-337.

[2] J. D. Bernal. *Science in History. The Scientific and Industrial Revolution*, Vol. 2, 3rd ed., MIT Press, 1971, p. 490.

[3] John H. Wilson, Jr., "Better Written Journal Papers—Who Wants Them?" *Science*, Sept. 5, 1969, p. 986.

[4] Cited by John C. Roney in "Problems in ERS Information Dissemination: Inside Perspectives." ERS Forward Look Contributed Paper, Sept. 1, 1976, p. 10.

[5] The recent *Agricultural-Food Policy Review* (January 1977) issued by ERS was a step in this direction. But some readers may have found even it a bit heavy in spots.

## RURAL TRANSPORTATION SYMPOSIUM

Concern has developed about trends in the cost of rural relative to urban transportation. Recent events have helped stir up this concern, among them the oil embargo of 1973, appropriation of several billion dollars for urban rapid transit in 1974, the exclusion in 1976 from CONRAIL of several thousands of miles of rural rail lines, and the action in 1976 making rural minor collector roads not eligible for Federal aid (resulting in decline of the Federal Secondary Highway System by about 170,000 miles). Demands for publicly sponsored research on these and other aspects of rural transportation have grown substantially.

ERS staff members early in 1976 discussed the research needs with persons at the Washington and Mississippi State Universities, among others. Out of these discussions came the suggestion for what became

the National Symposium on Transportation for Agriculture and Rural America, held in New Orleans, La., Nov. 15-17, 1976. Joint sponsors were USDA's Economic Research Service and Cooperative State Research Service (CSRS), the U.S. Department of Transportation (DOT), State agricultural experiment stations, the Farm Foundation, and the Upper Great Plains Transportation Institute. By and large the 230 attendants came from public and private organizations having a strong interest in rural transportation research and/or action programs. The overall objectives were to evaluate the state of knowledge and to identify additional knowledge needed about planning, policy, and impact analysis for transportation for agriculture and rural America.

Four keynote and five issue sessions were held. The keynote sessions were devoted to (1) the role of economists in transportation policy, (2) the need for impact assessments in a total systems context, (3) the organizational form needed for planning and making transportation policies, and (4) the need for ensuring equity for rural areas in future transportation investments and adjustments. The four keynoters, respectively, were John R. Meyer, Professor of Economics, Harvard University; Ann F. Friedlaender, Professor of Economics and Civil Engineering, Massachusetts Institute of Technology; Honorable William V. Alexander, U. S. Representative from Arkansas; and James W. Giltmier, Professional Staff Member, Committee on Agriculture and Forestry, U.S. Senate.

John Meyer concluded that economic analysis in transportation has served principally as an "early warning" system on basic trends and forces. Some areas in which he deemed economic knowledge is inadequate for guiding policy decisions include: the extent of cross subsidy in transport rate structures; the stability of current financing; and the relative efficiencies of mixed public and private systems, such as CONRAIL, versus totally public or private systems.

Ann Friedlaender discussed traditional views about transportation and its regulation, and assessed the state of knowledge about the validity of these views. In most cases, she found the knowledge to be inadequate for either accepting or rejecting the views. Friedlaender presented and discussed four linked models which can be used to examine transportation policies, and efficiency and distribution variables:

- A regional transportation model that determines costs, revenues, profits, outputs, shipment characteristics, rates, and factor demands by firm, mode, broad commodity type, and region.
- A regional income model that determines factor prices, consumer prices, incomes, outputs, and employment by broad commodity types.
- A national interindustry model that determines interindustry coefficients, commodity prices, commodity outputs, and factor employment by broad commodity types.
- A small-scale, national macroeconometric model that determines factor prices, final demands, and consumer prices.

Congressman Alexander discussed the lack of knowledge shown by planners and others about impacts from adjustments in rural transportation infrastructure. He stressed the importance of bringing broad experiences and diverse interests into the process of planning national transportation systems.

James Giltmier noted that program funding focuses much of the Federal, State, and local governmental revenues into solutions of urban problems. He called DOT's attention to the analytical capabilities available in USDA and land grant institutions for planning and impact analyses in connection with rural transportation. He also described the decisionmaking apparatus of the Senate with respect to transportation.

The five issue areas, for which each session included six or seven papers, were:

- Transportation of agricultural commodities for international trade
- Impacts of transportation regulation on agriculture
- People, commodity, and service transport in rural America
- Economics of freight transportation in low-density rural areas
- Impacts on rural transportation from changes in the energy situation and transportation policies

As it was a symposium drawing on broadly dispersed researchers and program managers, indepth analytical papers were not required. Nonetheless, several participants did report basic, indepth research. A paper by Andrew Daughety and Frederick Inaba of Northwestern University was titled "Modelling Service-Differentiated Demand for Freight Transportation: Theory, Regulatory Policy Analysis, Demand Estimation." The authors used a dynamic model of demand for freight transportation to analyze the feasibility of flexible (unregulated) rates. Differences in the quality of service provided by different modes were shown capable of generating stable intermodal competition, even when one mode has increasing returns to scale.

Phillip Baumel of Iowa State University, James Cornelius of Montana State University, and Arvin Bunker of ERS, among others, reported the results of indepth studies. Baumel examined rail rationalization for the State of Iowa; Cornelius assessed economic performance of the agricultural exemption in interstate trucking; and Bunker analyzed the impacts likely to accrue from waterway user charges.

Several authors presented situation and outlook assessments of various aspects of agricultural and other rural transportation. A panel of five transportation research users led a discussion of the state of knowledge and needs for further research. Divergence of views about the state of knowledge was probably greatest for the impacts of regulation; but opinion diverged considerably as to the research needed in the area of people and service transport—equity versus efficiency.

The symposium initiated useful interchanges among land grant and other researchers active in the area of rural transportation, and among researchers and research users. A proceedings including all formal papers and substantive discussions will be published by the Department of Transportation.

John O. Gerald
Leader, Transportation Economics
National Economic Analysis Division

Kenneth L. Casavant
Associate Professor of Agricultural Economics
Washington State University

## NATIONAL CONFERENCE ON NONMETROPOLITAN COMMUNITY SERVICES RESEARCH

In summarizing the National Conference on Nonmetropolitan Community Services Research at The Ohio State University, anchorman Jim Hildreth, Managing Director of the Farm Foundation, failed to elicit final answers to his question: "So what? Where do we go from here?"

That is probably as it should be.

The Farm Foundation, the Economic Development Division of ERS, and the North-Central and Northeast Regional Centers for Rural Development sponsored the conference held Jan. 11-13, 1977. Their aim: "to improve the quality of nonmetropolitan community services research for public decisionmaking at local, State, and Federal levels." This included identification of emerging problems, along with discussion of new theoretical approaches and findings.

The agenda focused on resources for and organization and delivery of nonmetropolitan community services. They were outlined in the opening taxonomic paper by Jerome Stam, leader of the ERS State and local government program area. There was emphasis in the conference on the interrelationships between researchable subjects and the disciplines studying them. There were papers on financing, intergovernmental revenue, current tax theory and policy for smaller governmental units, public choice theory and coordination of services, service cost-quality-quantity relationships, measuring output and consumer satisfaction, and needs assessment.

Research in community services calls for a broad disciplinary approach. Although the majority of attendees were agricultural economists, most of the nearly 30 papers were presented by economists, political scientists, public administrators, and sociologists. This mixture of disciplines created some problem in communication. But the program planners had allowed almost as much time for discussion as for presentations, and they kept the ratio of attendees to speakers close to 3:1. Their plan payed off. It often engendered heated debate that kindled light in dialog. Some—but not all—of this may be recreated by reading the proceedings, published by the Senate Committee on Agriculture and Forestry. They provide an overview of the current state of research in the broad field of nonmetropolitan community services research.[1]

Ron Powers, director of the North Central Regional Center for Rural Development, commented after the conference that:

> A multi- or pan-disciplinary approach is essential . . . The conference brought together a mix of people who began to understand each other, become interested in other approaches, and set the stage for further work . . . From feedback received after the conference, it appears that some social scientists in our region are interested in forming multidisciplinary research teams.

Donn Derr, a Rutgers University agricultural economist, pointed out that planning and funding for interdisciplinary research go together. Commonality of concerns is a necessary, but often insufficient factor in bringing about interdisciplinary research. It usually boils down to "buying their time," as Helgeson put it. Derr also said that he picked up an idea for further cross-sectional analysis of data already gathered for a Northeastern regional study. An analagous Great Plains Project, reported at the conference by Lonnie Jones, Texas A&M agricultural economist, was the catalyst.

Tom Hady, deputy director of ERS's Economic Development Division, observed:

> Five or ten years ago, a similar group would have been applying theory from marketing studies, etc. We are now developing theory which applies squarely to community services. At the same time, we now have a good range of applied studies on relevant problems. These studies are as important as the theoretic breakthroughs, both to guide the development of new theory and to make what we learn useful.

This latter point was reinforced by Lee Day, director of the Northeast Regional Center for Rural Development. "Elected representatives find it difficult to find what the people really want," he said. "New techniques with mail and telephone surveys can make preference surveys cheaper and more timely. New designs can avoid many of the pie-in-the-sky answers of previous surveys."

The proceedings reflect a blend of applied and theoretical strategies for research. "One [strategy] focuses on the problem of a specific unit of government with a pragmatic approach. The other develops a general set of relationships about a specific item for decisionmakers in a number of units of government. It is likely that both are useful," Jim Hildreth said in summary. He added:

> Establishing data series would have very high returns for community service researchers, and thus to users of their research. However, careful definition of the series and their uses will be needed . . . Measuring output of public services is complex and difficult. We need multiple indicators of output. Citizens *are* knowledgable about the quality aspect of public services. Thus, we can obtain useful and valid opinions from them.

After complimenting the planners of the conference, Alvin Sokolow, associate director of the University of California (Davis) Institute of Governmental Affairs, raised two caveats:

> The conference ignored the area of overlap between political science and sociology that I would label "political sociology" and which considers the processes whereby authoritative bodies make important decisions at the community level . . . No mention was made of the classic study of American rural politics—Vidich and Bensman's *Small Town in Mass Society*.

Don Dickson
Public Information Specialist
Information Division

[1] Committee on Agriculture and Forestry. *National Conference on Nonmetropolitan Community Services Research*. U.S. Senate Committee Print, for sale by Sup't. Docs., U.S. Govt. Print. Off., Wash., D.C. 20402. 1977. (Price not yet determined).

## FORECASTING U.S. EXPORT UNIT VALUES *

To forecast the value of U.S. farm exports, USDA analysts use unit values rather than prices. The export unit value is the total reported value of a specified commodity exported divided by the reported quantity, and it represents a weighted average export price. Monthly export unit values are published by the U.S. Department of Commerce, normally about a month after the actual exports. Spot prices can be used to predict export unit values 1 to 2 months in advance.[1] But predictions of export unit values are needed for the fiscal year (October-September) as early as the previous September. In addition, these estimates are usually made in December, March, and June. In ERS, these estimates are reflected in quarterly analyses and in the *Outlook for Agricultural Exports.*

Futures prices and cash prices have been tested in ERS as exogenous variables on which to base needed forecasts. Regression estimates of export unit values for fiscal years 1966-76 are presented here for wheat, but models were also tested for corn and soybeans.

Futures prices reflect traders' expectations. Prices at the beginning of a crop year—July for wheat—are typically at their seasonal lows. Thereafter, prices tend to increase, reflecting accumulated storage costs. Futures prices for the later months of a crop year tend to match anticipated cash prices. To the extent that futures prices reflect distant cash prices, they should be useful inputs to ERS forecasts of export unit values.

Cash prices might also serve as predictors of export unit values. Until 1972, cash prices and export unit values did not change drastically during the course of a crop year. Moreover, cash prices are closely linked with futures prices by the cost of storage.

The dependent variables in the forecasting equations examined here were the export unit values obtained from monthly U.S. export data for fiscal years 1966-76. The export unit values excluded U.S.-Soviet trade because the United States made long-term grain contracts with the USSR before the sharp rise in grain prices occurred. Also, the export unit value of wheat was adjusted to include subsidies that the U.S. Government granted to wheat exporters until August 1972, since commercial wheat exporters took these subsidies into account in their market transactions.

The independent variables were futures price quotations and monthly cash prices. The monthly futures prices were computed as simple averages of the daily closing quotations for a month which was a specified number of months prior to the closing date of the futures contract, as reported for the Kansas City Grain Exchange in the *Wall Street Journal.* Wheat futures were quoted for March, May, July, September, and December. The monthly cash prices were for No. 1 hard winter wheat, ordinary protein, at Kansas City.

Four alternative forecasting equations were considered:

1. Method 1—The estimated annual export unit value for the fiscal year (October-September) is set equal to the year—earlier value:

$$EUV_t = EUV_{t-1}$$

This is a naive approach, used as a benchmark for evaluating the alternative approaches. It explained about three-fourths of the variation in unit values (table 1).

2. Method 2—The estimated annual export unit value is a linear function of cash price:

$$EUV_t = a + b\ CP_m$$

where $CP_m$ is the monthly cash price. The annual export unit value for wheat was regressed respectively against the September, December, and March cash prices (table 1).

3. Method 3—The estimated annual export unit value is predicted as a linear function of the futures price:

$$EUV_t = a + b\ FP_m^n$$

where $FP_m^n$ is the monthly futures price that matures in month *n*. The annual export unit value for wheat was regressed respectively against the March futures price quoted in December and May futures price quoted in September (table 1).

4. Method 4—Estimates of the fiscal year export unit values are a function of futures contracts; the equation is described in the following paragraphs.

Estimates of these export unit values are required for

Table 1.—Equations for predicting annual export unit values for wheat (methods 1, 2, and 3)

| Method | Estimator | $R^2$ | $t$ test for B = 1[1] |
|---|---|---|---|
| Method 1 | $EUV_{t-1}$ | 0.742 | |
| Method 2: | | | |
| Wheat | | | |
| $EUV_t$ | = .383 + .918 CP September | .972 | 1.607 |
| $EUV_t$ | = .367 + .908 CP December | .949 | 1.329 |
| $EUV_t$ | = .233 + 1.004 CP March | .935 | .045 |
| Method 3: | | | |
| Wheat | | | |
| $EUV_t$ | = .378 + .945 FP May September | .962 | .949 |
| $EUV_t$ | = .392 + .911 FP March December | .958 | 1.412 |

[1] At the 10-percent level of probability, none of the B values is significantly different from 1.0, based on the T ratio of 1.67.

[1] Economic Research Service. Selected Prices of International Significance. In *Foreign Agricultural Trade of the United States,* U.S. Dept. Agr., May 1975.

*The author gratefully acknowledges the expert advice given by Richard G. Heifner, National Economic Analysis Division, Economic Research Service on the preliminary draft of this paper.

ERS outlook reports quarterly in September, December, March, and June. During the fiscal year, actual export unit values progressively become known. Method 4 attempts to take advantage of the new information. For example, in December, export unit values for October and November become known. The known export unit values for these early months are combined with estimates for the remainder of the year. Weights are determined by the quantity distribution of wheat exports of the previous fiscal year. Estimated export unit values are a function of futures contracts. If one is estimating the FY export unit value in December, one has access to future quotes for contracts to expire in December, March, May and July. The December futures can be used to estimate unit values for December-February, March futures for March-April, May futures for May-June, and July futures for July-September.

The monthly export unit values were estimated from the equations from table 2 that applied respectively to the forecast intervals. For the December forecast, intervals are used of "within the month," 3 months, 5 months, and 7 months. These are based on the number of months between the December price quotation and the closing dates of the relevant futures contracts (table 3). Similar estimates of the fiscal year export unit values were made in September, March, and June using the scheme of table 3, the most timely known export unit values and futures prices available on those dates, and the estimating equations in table 2. The estimating equations are based on the historical (1965-75) relationships between monthly export unit values and futures prices.

Table 2.—Equations for predicting monthly export unit values for wheat (method 4)

| Forecast interval in months | Intercept | B value | $R^2$ | T test[1] for B=1 |
|---|---|---|---|---|
| 0[2] | 0.24 | 1.004 | 0.884 | 0.083 |
| 1 | .26 | .993 | .943 | .205 |
| 2 | .25 | 1.012 | .952 | .387 |
| 3 | .22 | 1.025 | .955 | .806 |
| 4 | .22 | 1.033 | .937 | .891 |
| 5 | .30 | 1.007 | .898 | .149 |
| 6 | .279 | 1.024 | .874 | .453 |
| 7 | .319 | 1.007 | .844 | .118 |
| 8 | .32 | 1.031 | .806 | .443 |

[1] At the 60-percent level of probability, none of the B values differs significantly from 1.0, based on the T ratio of 1.67. [2] Within the month.

The export unit value for a given month was regressed on the futures price quoted $n$-$m$ months earlier (where $n$ = date of closing and $m$ = date of quotation). For example, to estimate the March unit value in December, the equation with a 3-month forecast interval ($n$-$m$=3) is used. That equation is based on five 3-month intervals in each year: December-March, February-May, April-July, June-September, and September-December. There are 11 years of data, so the total number of observations in each regression is 55.

Forecasts based on monthly cash or future prices (methods 2 and 3) generally provided the best estimates early in the fiscal year. Combining the monthly predictions of export unit values obtained from the regression with the already known export unit values was better later in the fiscal year.

In September, the best estimate for the fiscal year unit value of wheat exports came from the regression based on the Kansas City May futures price quoted in September (method 3). In December and March, combining regression estimates from monthly futures price data and already known export unit values data (method 4) provided estimates with the least average absolute error.

Analogous models were also tested for corn and soybeans. For corn, the results were generally the same as

Table 3.—Futures quotations used to predict EUV's method 4

| Month prediction is made | Month predicted— | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct. | Nov. | Dec. | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. |
| September | Sept.(0) | Sept.(0) | Dec.(3) | Dec.(3) | Dec.(3) | Mar.(6) | Mar.(6) | May(8) | May(8) | May(8) | May(8) | May(8) |
| December | A | A | Dec.(0) | Dec.(0) | Dec.(0) | Mar.(3) | Mar.(3) | May(5) | May(5) | July(7) | July(7) | July(7) |
| March | A | A | A | A | A | Mar.(0) | Mar.(0) | May(2) | May(2) | July(4) | July(4) | Sept.(6) |
| June | A | A | A | A | A | A | A | A | May(0) | July(1) | July(1) | Sept.(3) |

Key to items in field:

A = actual price.
Dec. = December future.
Mar. = March future.
May = May future.
July = July future.
Sept. = September future.

Note: The number in parentheses is the forecast interval in months representing the time interval between the price quotation and closing date of the contract, and it applies to the estimating equation in table 2 that would apply to futures contract that is quoted in month the prediction is made.

for wheat. That is, the regression analysis using the March futures prices quoted in September and December (method 3) yielded the best early forecasts. Forecasts in March based on combining the regression estimates based on monthly futures price data and already known export unit value data (method 4) provided the best fit.

For soybeans, the regression analysis using the September Chicago cash prices (method 2) yielded estimates with the lowest average absolute error for those months. In December, the price ratio between the current and previous year's December Chicago cash price for soybeans yielded the best results (a modification of method 2). The regression analysis using monthly futures prices combined with the already known export unit values yielded the best March estimate (method 4). These methods (table 4) have been chosen as the "best" methods for estimating fiscal year export unit values of wheat, corn and soybeans. Estimates from these methods are currently included in the ERS publication *Outlook for Agricultural Exports* and in quarterly ERS short-term projections of the value of U.S. agricultural exports.

H. Christine Collins
Agricultural Economist
Foreign Demand and Competition Division

## IMPACTS OF HAIL SUPPRESSION IN NEBRASKA

We have speculated for years on the possible effects of reduced hail damage on farm income, crop distribution, cost of production, factor suppliers, and community businesses. In the United States, technology that can be used to suppress hail is being applied experimentally—to improve techniques through basic research; and commercially—through contracts between a group of farmers and an applicator. It is important to weigh the likely costs and benefits.

A study by the Economic Research Service, in cooperation with the National Science Foundation, simulated and estimated the annual effects on crop production for different rates of hail suppression.[1] The study, limited to Nebraska, focused on analyzing shifts in location of crop production that might occur from changes in the comparative advantage of 10 substate areas. One working hypothesis was that hail risks would differ markedly from one geographic area to another, and that the impact of hail suppression on the competitive positions of geographic areas would be more significant than would changes in aggregate production and cost.

[1] To simplify this presentation, I have omitted most of the hard data. Further, detailed information can be obtained from William M. Crosswhite, Assistant Director, Natural Resource Economics Division, ERS.

Table 4.—Export unit values for wheat, actual and selected forecasts, 1965/66 to 1975/76

| Fiscal year | Actual export unit value for wheat | Predicted export unit value for wheat based on— | | | | |
|---|---|---|---|---|---|---|
| | | $EUV_t$-$EUV_{t-1}$ (Method 1) | May future quoted in Sept., Kansas City (Method 3) | Future prices quoted in Dec. and known export unit values for Sept.-Nov. (Method 4) | Futures prices quoted in March and known export unit values for Sept.-Feb. (Method 4) | Futures prices quoted in June and known export unit values for Sept.-May (Method 4) |
| Time information is available | Hindsight | Before year begins | September | December | March | June |
| | | | | *Dollars/bushel* | | |
| 1965/66 | 1.90 | 1.72 | 1.80 | 1.84 | 1.83 | 1.85 |
| 1966/67 | 1.87 | 1.90 | 2.19 | 2.10 | 2.04 | 1.93 |
| 1967/68 | 1.68 | 1.87 | 1.91 | 1.80 | 1.81 | 1.69 |
| 1968/69 | 1.67 | 1.68 | 1.70 | 1.67 | 1.64 | 1.64 |
| 1968/70 | 1.69 | 1.67 | 1.65 | 1.66 | 1.66 | 1.66 |
| 1970/71 | 1.72 | 1.69 | 1.81 | 1.83 | 1.73 | 1.73 |
| 1971/72 | 1.79 | 1.72 | 1.74 | 1.75 | 1.75 | 1.75 |
| 1972/73 | 2.65 | 1.79 | 2.15 | 2.61 | 2.34 | 2.44 |
| 1973/74 | 4.66 | 2.65 | 4.64 | 4.94 | 4.97 | 4.62 |
| 1974/75 | 4.71 | 4.66 | 4.61 | 4.96 | 4.44 | 4.36 |
| 1975/76 | 4.29 | 4.71 | 4.43 | 4.07 | 4.28 | 4.22 |
| $\Sigma d_i^2$ * | | 5.03 | .46 | .28 | .32 | .18 |
| $\sqrt{\Sigma d_i^2}$ | | 2.24 | .68 | .52 | .56 | .43 |
| | | | | *Cents/bushel* | | |
| $\Sigma d_i/N$ | | 32.9 | 14.7 | 12.5 | 12.5 | 7.8 |

*$d_i$ is the difference between actual and predicted export unit value.

Estimates of hail suppression costs varied from 3½ cents to about 6½ cents per acre. Compared with other production costs, differences in hail suppression costs were rather insignificant, so the suppression cost used in the analysis was 5 cents per acre. Three levels of hail suppression effectiveness were assumed: 10, 25, and 50 percent.

Constant prices received by farmers were used, reflecting an assumption that the aggregate demand and price situation is not affected by hail suppression technology. However, if such technology were widely used, it could influence production of some crops enough to change prices. The mix of crops after hail suppression is influenced by relative net revenues. The location of a crop is influenced by what happens to competitive positions of geographic areas for production and prices. Simulating annual changes in production expense by area (average cost per acre) permitted some tentative indications of the change in factor demand.

Results indicate that hail suppression will not affect aggregate levels of production and cost much in Nebraska. Eliminating as much as one-half the estimated hail loss for the areas studied would result in relatively small aggregate gains. The simulation provides insights at an early stage when such information should be of maximum value. The model examined increased production and demand for factors for a single crop in a single area. In addition, a simulation over several areas with several crops provides insights into interactions between crops in the same area as well as shifts in location of a crop between two areas.

Simulated changes in acreage among crops within geographic areas in Nebraska were generally minor but some shifts occurred among areas. In only two cases did any of the 10 areas gain or lose more than 1 percent of their total cropland, and none changed as much as 2 percent. Thus, hail suppression would cause neither massive shifts in location of production in the State nor large acreage shifts among crops within a region. Suppressing hail did increase total crop production. The distribution of the increase and the implications for the demand for factors were more significant than the acreage changes.

Reducing production costs per unit of output helps the grower, but it may decrease the demand for some farm inputs, thus having a negative social aspect. However, total changes in production costs were nominal in the Nebraska simulation. Changes in total factor demand varied considerably among regions where hail was suppressed, partly because of acre shifts but mostly because of changes in output. Total production costs (exclusive of land and management charges) ranged among areas from a reduction of about 4 percent to an increase of nearly 5.5 percent. If the Nebraska results apply in other areas affected by hail, even total factor demands in most rural communities would likely change little if hail were suppressed.

Larry Boone
Natural Resource Economics Division



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